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## CONTENTS AND INDEX.

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# CONTENTS.

VOL. XXXVI, January–June, 1906.

**For alphabetical index, see page v.**

# INDEX.

VOL. XXXVI, January–June, 1906.

ABBREVIATIONS. — P = Paper; D = Discussion; I = Illustrated. Names of authors of papers, etc., are printed in *italics*.

PAGE

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## AN EFFICIENT MODERN STEAM PLANT IN FLOUR-MILL SERVICE.

By William H. Bryan, Member of the Engineers' Club of St. Louis.

[Read before the Club, September 20, 1905.]

The object of the investigation herein reported upon was to ascertain the efficiency of a new power plant, considering the boiler and engine independently, and the mill as a whole, comparing the coal burned with the work done and flour made. A further object was to compare these results with the efficiency of the same mill before the new machinery was put in; also to determine the adjustment of all parts, whether the engine was doing its proper share of the work, and what parts, if any, were in need of further adjustment. Also what units were less economical than others, and what further improvements or adjustments, if any, could readily be made.

### The Mill.

This plant is owned by the Wolff Milling Company, and is situated at New Haven, Mo., a town of about 1 500 inhabitants, 67 miles west of St. Louis on the Missouri Pacific Railroad, located on the south bank of the Missouri River, which stream forms the northern boundary of Franklin County.

The mill is what is called a 400-bbl. mill, that being its nominal output of flour in 24 hr. It is customary, however, to run the mill only 12 hr. per day, but its rating per hr. can readily be exceeded 10 per cent. or even more, under favorable conditions. In addition, there is the usual grain elevator, stones for grinding corn meal, and machinery for the manufacture of

graham flour. These, however, are in operation only occasionally. The old power plant having about outlived its usefulness, the author was asked in January, 1905, to look into the condition of that plant, the work it was doing, its efficiency, etc.

## Former Power Plant.

The old plant was installed in 1881, and was, therefore, nearly 24 years old. It consisted of two horizontal return flue boilers, of the " compromise " pattern, so popular at that time. The boilers were each 48 in. diameter, 20 ft. long, and had 12 6-in. flues. They were set in a single furnace, with common grates, 4 ft. long, 9 ft. wide; iron chimney 36 in. diameter, 73 ft. high. These boilers were rated at 50 h.p. each. This type of boiler, as is well known, can readily be crowded to twice its rated capacity, and even more, which conditions of operation are not at all uncommon. The boilers were fed by a " doctor " — a vertical fly-wheel feed pump — having two single-acting plungers, $2\frac{13}{16}$ in. diameter by $4\frac{1}{2}$ in. stroke, discharging through an iron pipe coil heater. The water supply came from a driven well 7 in. diameter, 235 ft. deep, the water in which stood at a depth of about 60 ft. below the surface with active pumping, and was of the uniform temperature of 58 to 60 degrees fahr. the year round. Water from this well was delivered into an overhead tank by means of a deep well pump, with 6 in. by 24 in. steam end and $3\frac{3}{4}$ in. by 24 in. single-acting water end, its speed being from 25 to 50 rev. per min. The mill was driven by a simple non-condensing Corliss engine 16 in. by 42 in., speed 70 rev. per min., built by the Smith, Beggs & Ranken Machine Company.

## Test of Old Plant.

In order to get an approximate idea of the efficiency of the old plant an informal test of 4 hr. duration was run on the afternoon of January 3, 1905. The coal burned was weighed, the engine indicated and the output of flour noted. An attempt was also made to estimate the water consumption by counting the speed of the " doctor," but the results were only approximate, and are of doubtful value. The results were as follows:

| | |
|---|---|
| Average gage pressure | 98.2 lb. |
| Flour made, bbl., total | 68.25 |
| Flour made, bbl. per hr. | 17.06 |
| Average speed of engine | 70 rev. per min. |
| I.h.p. | 171.2 |
| I.h.p. per bbl. per hr. | 10 |

| | |
|---|---|
| I.h.p. per bbl. per day of 24 hr. | 0.42 |
| Rating of engine | 135 h.p. |
| Proportion capacity developed was of rating | 125 per cent. |
| Coal burned, total | 3 325 lb. |
| Coal burned per hr. | 831 lb. |
| Coal burned per hr. per sq. ft. grate | 23.1 lb. |
| Coal burned per hr. per i.h.p. | 4.85 |
| Coal burned per bbl. flour | 48.7 |

The coal consumed was screened lump from the Jupiter mines near the DuQuoin, Ill., costing $2.73 per ton delivered. This coal is above the average quality which comes to the St. Louis market, but is, of course, not quite equal to the highest grades from southern Illinois, such as the Big Muddy.

The grain elevator, requiring about 20 h.p. additional, was on during this run, but not the corn or graham mills. The horse-power developed was a little large, owing to the heavy feed customary in cold weather. It is possible also that the mill had not gotten down to smooth, well lubricated running conditions after the holiday shut down.

### Conclusions and Recommendations.

The result of this informal test, and the conclusions and recommendations based thereon, were handed the company in a formal report on January 18, 1905. Special emphasis was laid on the fact that the modern flour mill offered exceptional opportunities for high fuel economy on account of its large and uniform load and the long hours of service, always at least 12 hr. per day, and often 24. It is a matter of some surprise that this field has been given so little attention heretofore among mills of average size. Among the plans analyzed in the Wolff report were the following:

*A*. The continued operation of the plant as it stood, adding only a new boiler. Estimated fuel saving over old plant, 20 per cent.

*B*. The adding of condensing apparatus to the existing engine. Total estimated saving, 40 per cent.

*C*. Substitution of two new cylinders for the old single cylinder, making the engine a compound, and running it non-condensing. Total estimated saving, 40 per cent.

*D*. Adding two cylinders, and also condensing apparatus. Total estimated saving, 55 per cent.

*E*. Installing an entirely new engine, to be compound non-condensing. Total estimated saving, 40 per cent.

*F*. Installing a new engine, to be compound condensing. Total estimated saving, 55 per cent.

Each scheme was fully discussed, its probable cost estimated and the probable resulting economy computed. Each plan contemplated the substitution of a new boiler of such capacity as was necessary, as follows:

Plan A, a 150 h.p. boiler, 72 in. by 20 in. with 74 4-in. tubes.

Plans B, C and E, a 115 h.p. boiler, 66 by 20, with 56 4-in. tubes.

Plans D and F, a 100 h.p. boiler, 60 in. by 20, with 46 4-in. tubes.

Further investigation indicated that the addition of a superheater to the boiler would bring about an economy fully justifying its cost, and this course was decided upon. No information was available as to the exact economies which would result, but a study of other installations indicated that an economy of at least 10 per cent might reasonably be expected.

An investigation was also made into the desirability and cost of economizers; also of tile and concrete chimneys, but the resulting advantages in this particular installation did not seem to warrant the additional investment.

Due consideration was given these data, with the result that the undersigned was directed to prepare detailed plans, and secure proposals on the basis of Plan F, involving an entirely new plant, especially designed for the work.

## The New Plant.

In due time proposals were received and contracts awarded for the new equipment. This was duly delivered and erected, consisting in detail of the following:

*Boiler.* — The admitted advantages of the water tube type for many kinds of service not being important in this installation, the ordinary horizontal return tube boiler was selected. Its dimensions were 60 in. diameter, 20 ft. long, with 46 4-in. tubes. Repeated evaporative trials have shown this to be a very economical type of boiler. The detailed design involved some special features, such as adjustable overhead supports, absence of steam dome, none being required for steady load, overlapping strips for brick work, etc. Deflecting dampers were placed over the four upper rows of tubes to divert a larger percentage of the gases into the lower flues. A sheet iron chimney 30 in. diameter, 100 ft. high, was placed immediately over the smoke box extension. The heating surface of this boiler was 1 173 sq. ft. in the

shell proper, and 58 in the down draft furnace, total 1 231, which at 12 sq. ft. per h.p. gives the boiler a rating of 102.6 h.p. The grate surface being 22.5 sq. ft., the ratio of heating to grate was 54.71 to 1.

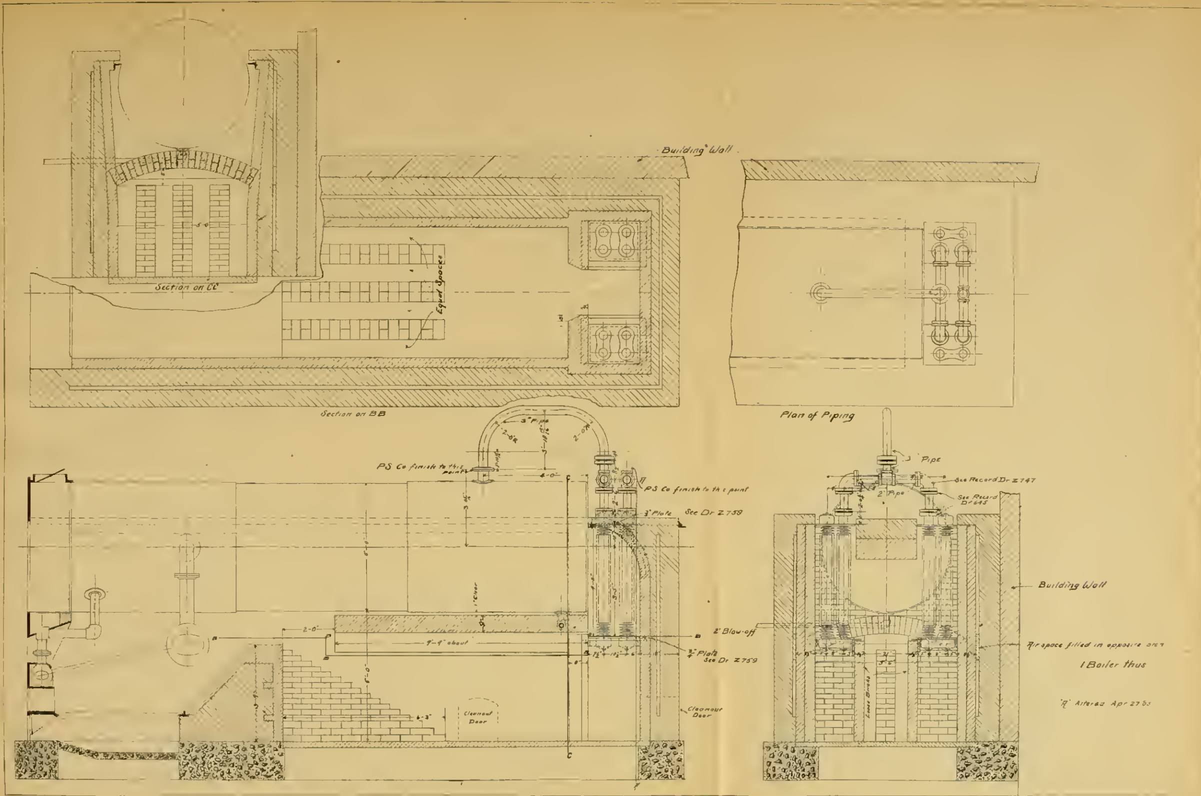
*Boiler Setting.* — The excellent performances in St. Louis of the down draft form of furnace led to its adoption, not on account of its smokelessness, but for its economy in fuel. A 10-in. drum with hand hole was used for the front header, and a 20-in. drum with man-head for the rear. The grates were made of 2½ in. extra heavy pipe, 2⅞ in. outside diameter, 5¼ in. centers, there being 12 in the furnace. The lower grates were of the ordinary type, 5 ft. in length. In addition the Kent wing-walls and arches were placed in the rear of bridge wall, primarily to insure a more uniform heat for the superheater, but they have no doubt added to the efficiency of the plant. The upper fire door of the down draft furnace extended the entire width of furnace, without columns, permitting access to and inspection of every portion of the fire bed.

*Superheater.* — This was of the Foster make, and was guaranteed to heat 3 000 lb. of steam per hr., at 150 lb. pressure, to 500 degrees fahr. The steam on leaving the boiler shell turns to the rear, and enters the superheater, dividing into two paths, each consisting of four elements. The steam descends through the furnace into a return header, then ascends, and then repeats the path, discharging finally into main steam line overhead. The other branch takes a similar course. The units consist of a length of 4-in. pipe about 4 ft. 4 in. long, surrounded by cast-iron washers, closely fitted to pipe, and of about 10 in. outside diameter. These receive the direct impact of the heat and bear the brunt of the wear and tear, protecting the pipes themselves, which are under pressure, and they serve furthermore as storage reservoirs of heat. Inside the pipes are placed pipes 3 in. diameter, which force the steam in its passage through the superheater to traverse the annular channels close to the walls of the pipe, in thin cylindrical streams, thus greatly facilitating its heating. The superheater is located in the area way between rear head of boiler and rear furnace wall. The gases pass first through the down draft furnace, and the Kent wing-walls and arch, and are discharged through a throat immediately below rear head of boiler. The two divisions of the superheater are located on each side, and are surrounded by fire brickwork, being thus protected from direct contact with the flame.

*Engine.* — This contract was awarded to the St. Louis Iron & Machine Works of St. Louis, and covered one of their standard tandem Corliss engines, high-pressure cylinder 12 in. diameter, low-pressure 24 in. diameter, stroke 36 in., speed 80 rev. per min. This engine, with an initial pressure of 150 lb., cutting off at $\frac{1}{4}$ in the high-pressure cylinder, and with 26 in. vacuum, is rated at 175 h.p. It was provided with a fly wheel 15 ft. in diameter, 30 in. face, built crowning for a 28-in. belt. Both cylinders were controlled by a single governor and eccentric, there being no necessity for severe overloads. A receiver between high- and low-pressure cylinders was provided and furnished with reheating coils to be supplied with superheated steam. The packing of pistons, stuffing boxes and all joints was metallic, and of a type specially adapted to superheated steam.

*Condenser.* — This was of the Wainwright horizontal type, having a cast-iron shell 18 in. diameter, containing 96 1-in. corrugated copper tubes, 96 in. long, with 256 sq. ft. of tube surface. The tubes were arranged in four groups with horizontal partitions, the water — which is inside the tubes — having to traverse the entire length of the condenser four times. This condenser is rated at 200 h.p. and was guaranteed to condense 3 000 lb. of steam per hr. to a 26-in. vacuum with not exceeding 6 500 gal. of water at 60 degrees fahr. Immediately under the condenser was located the wet vacuum pump, $5\frac{1}{2}$ in. by 8 in. by 7 in. The surface type of condenser was selected at a slightly greater cost than the jet type, on account of its increased simplicity and reliability and its giving a supply of purified water for the boiler, thus doing away with the necessity for frequent cleaning and the risk of burning.

*Deep Wells and Pumps.* — In addition to the original deep well referred to above, the Wolff Company sunk another well of the same dimensions and depth, installing in same the old deep well pump. For the old well an order was placed for a new deep well pump, 6 in. by 36 in. steam end, and $5\frac{3}{4}$ in. by 36 in. single-acting water end. The new well was located at a point some 30 ft. distant from the original well, and probably tapped the same vein of water. It was found that the two pumps working together gave a somewhat greater capacity of water than either of them singly, but both cannot be operated to their full capacity at the same time. They furnish, however, a sufficient supply of water for circulation through the condenser, and discharge directly through same, provision being made to take some of the




Foster Superheater and Kent Wing-wall Furnace for the Wolff Milling Company, New Haven, Mo.

warm discharge water for "make-up" water through the hot well to boiler, and also for filling overhead tank for use when the plant may be shut down.

*Pipe Work.* — This was made simple and direct, bends being used wherever possible. The main line carrying superheated steam was made 3 in. diameter, and provided with extra heavy valves and fittings. This size was much smaller than ordinary practice, and as its total length — including travel through superheater — was nearly 100 ft., its use was attended with some misgivings. The best practice of the present day is to reduce these sizes, particularly with superheated steam. A receiver 18 in. diameter, 36 in. long, was, however, placed at the engine immediately above 4-in. throttle valve, with a view of equalizing the pressure at the engine. No separator or drain was provided for same. All joints in high-pressure line were of two thicknesses of sheet copper. Traps were provided on exhaust from high-pressure cylinder and on reheating coil in intermediate receiver, the former discharging to waste on account of the oil, and the latter discharging into hot well. The exhaust leaving low-pressure cylinder crosses engine room under ground, then rises to a T, above which is the 8-in. free outlet to atmosphere, in which was located a Blake relief valve. From side of T the exhaust continues to the Wainwright condenser through a Bundy grease extractor. The latter drains into a 12 in. by 40 in. receiver with water column, which receiver is provided with a high-pressure connection from boiler and a drain to sewer. It has been found necessary to blow this receiver out about once every 3 hr. This is done by closing the valve from separator, opening steam valve slightly and then opening drain. The air pump discharges into the hot well, which consists of an old boiler shell 40 in. diameter, 8 ft. long, set up vertically. It has a perforated false bottom, above which there is placed some 3 or 4 ft. of hay, which is frequently renewed. There is a surface overflow or blow-off, and the water filters down through the hay into a lower compartment, from which it passes to the "doctor." The original extraction of grease before entering condenser, and the further filtering through hay, with an occasional blowing off of the surface of hot well, have been found entirely satisfactory thus far in keeping oil out of the boiler. In the hot well there is an automatic float controlling a valve in a branch pipe from the circulation discharge, which admits such make-up water as may be required. The feed water passes from the hot well to the "doctor," thence through coil in heater to boiler. It was found

impractical to use an open heater, and a Hoppes shell 34 in. diameter by 8 ft. long from the old plant was retained and filled with 1.5 in. pipe and return bends. Into this heater the exhaust from the two well pumps, the "doctor," and the air pump are discharged, with very efficient results in heating the feed water, as is shown by the test. In order to insure a thorough distribution of the steam in the heater, the atmospheric discharge was reduced to 1 in., which has been found ample. The condensation in heater passes to hot well and forms no inconsiderable portion of the make-up water necessary. The main steam line carrying the superheated steam is covered with magnesia covering of double thickness. The top of boiler, and other steam lines carrying saturated steam, were given a single thickness of the same covering. This included intermediate receiver, the high-pressure receiver having double thickness. An independent steam line from the boiler supplies saturated steam to the four pumps.

Before the formal efficiency test was conducted, an investigation into the drop in pressure between the boiler and engine was made with a test gage. It was found that when the engine was running at about 150 h.p., with 155 lb. gage pressure, there was a drop of but 4 lb. between the boiler and the receiver at engine throttle. This included the entire 3-in. steam line and the superheater, and was found to be about equally divided between the superheater and the pipe line.

*Power Transmission.* — In the old plant the Corliss engine shaft extended through mill wall, where the mill was driven by a complicated system of spurs and gearing, the overhead transmission being by means of a vertical shaft. This was changed, doing away with a considerable portion of the gears. Provision was made for extending the main mill shaft into old engine room and locating on same an 80-in. pulley, which was driven by a belt direct from engine fly wheel, the new engine and boiler rooms being located in a new building directly west of the old one. The distance between wheel centers was 28 ft. 9 in. The transmission was by means of a 28-in. Shultz 3-ply "Sable" leather belt, rated at 300 h.p.

In arranging the plant, particular attention was given to compactness and easy access to all parts, the intention being that a single man should do the firing and look after the power plant. As less than 400 lb. of coal were to be fired per hr., and as the load was practically constant, this requirement was not deemed unreasonable. The boiler and engine were so located

that the attendant might pass quickly from the fire room to the engine, all starting and controlling mechanism being near at hand. The three main pumps were also located near by. The engineer, standing in the door between boiler and engine room, has his eye upon practically the entire power plant, and is within a half dozen steps of all features requiring frequent attention. The only parts at any distance are the main engine bearing and crank pin, which require only occasional inspection.

### Preparations for the Test.

The gages around the plant had already been compared with a standard test gage, and their corrections noted. Three calibrated water measuring tanks were shipped to New Haven, and erected in such position as to take either the water discharged into hot well from condenser, or the make-up water. The discharge from these tanks went direct to the "doctor." The drain from heater was disconnected from hot well and allowed to go to waste, as it was of no particular importance in the test. The discharge from engine receiver trap was also disconnected from hot well, and carried to a barrel for periodical weighing. Tested scales were provided for the coal and ashes. The steam being superheated, no calorific determinations for dryness were necessary. The blow-off pipes from boiler were plugged. An indicator was provided for the high-pressure cylinder, and another for the low-pressure, so that cards could be taken from both simultaneously. A revolution counter was attached to the valve motion of the engine, so that its exact number of revolutions for any given interval could be ascertained. An ample supply of thermometers was provided for measuring temperatures of steam at outlet of superheater and at engine receiver; also where steam entered and left reheating receiver. Thermometers were inserted in chimney, feed line near boiler, hot well, measuring tanks, circulating water inlet and outlet, and for external and internal air. Draft gages were provided for measuring the chimney draft, both at base of chimney and in fire box between grates. The feed water supply was from air pump discharge as far as it would go, the remainder or make-up water being from circulating discharge. It will be noticed that this make-up was necessarily greater, and that the temperature of feed water through "doctor" was lower, than it would have been had the drains from heater and engine trap gone to hot well as in ordinary running. A previous test showed the water

from condenser to be 120 degrees fahr., and in hot well, 142, a gain of 22 degrees.

A preliminary run was made on the afternoon of August 14, to see that all instruments and apparatus were in working order, and to drill the assistants in their special duties.

## The Test.

This was begun at 8 A.M., August 15, 1905, and continued uninterruptedly until 6 P.M. Indicator cards and observations of all general readings, such as pressures and temperatures, were taken every 20 min. The moment of observation, however, was at the middle and not at the beginning of each 20 min. interval. Independent logs were kept by each observer, or assistant, and these were double checked wherever possible. No attempt was made to reach all the refinements possible in modern engine testing, where exact heat balances are desired, or where important questions hinge on the result. It was desired simply to ascertain with accuracy the essential facts of mill output, horse-power temperatures, and water and coal consumption.

*The Fuel.* — This was large nut, or No. 1, washed, from the Carterville district in Williamson County, southern Illinois. It was quite uniform in size, clean and of excellent quality. A small shovelful was thrown into a sample barrel from every barrow load throughout the run. At the close, this was quartered down into a small sample and preserved in a Mason jar for later calorific determination and proximate analysis, if desired. Previous investigations of this coal indicate that it has a probable calorific value of about 12 000 B.t.u. per lb., which figure has been used in the present computations. The coal was delivered to the fireman in 500-lb. lots, the time of the first fire from each new lot being noted on the log. No special instructions were given the fireman, other than to carry uniform boiler pressure, uniform thickness of fire, and to avoid air holes. The fires were thoroughly cleaned just before beginning the test, and filled with fresh coal, and when this had burned down to the point of requiring replenishing, the time was noted and the test begun. A similar cleaning of the fire was made just before the close of the run, after which the fire was charged with weighed coal, which was again allowed to burn down at the close. The fireman was a new man, who had never fired a boiler before the starting up of the new plant, but, having no preconceived ideas, had nothing to unlearn, and proved very faithful

and efficient in doing what was expected of him, a characteristic not always found in more experienced stokers.

*Water.* — This was put through calibrated measuring tanks, Nos. 1 and 2, with knife-edge overflows, these being filled and emptied alternately into No. 3. Previous to starting the test, tank No. 3, which serves as a reservoir for the boiler feed pump to draw from, was filled to overflowing. Tank No. 1 was also filled, ready for use, and No. 2 was empty. At the moment of starting the test the height of water in the boiler and hot well were noted, and the feed pump began to draw from No. 3. At the same instant the discharge water from air pump and condenser was turned into No. 2. Tanks 1 and 2 were then filled and emptied alternately, except when the supply from condenser ran short of the boiler's demand, when an extra and intermediate tank was filled from the circulating water from condenser. The height of water in boiler was kept close to the starting point all day, and was brought to exact level at the close. Temperature readings were taken at the time of overflow in each measuring tank, so as to get its exact volume and weight from charts representing previous calibrations.

*Miscellaneous Data and Records.* — Indicator cards were taken from both ends of both cylinders simultaneously every 20 min., and all gages and thermometers were read, and the pressures and temperatures noted on logs.

## Results of the Test.

*Boiler and Superheater* (see Exhibit B). — The boiler pressure was maintained fairly uniform, averaging 150.7. The draft at base of stack ranged between 0.3 in. and 0.5 in., and in fire box between grates 0.1 in. and 0.3 in. These readings were rather lower than anticipated, and are due, no doubt, to the high external and low stack temperatures. The latter ranged between 362 and 460, a very low figure, due in part to the presence of superheater, and in part to the fact that the boiler was not being crowded. The temperature of steam leaving superheater ranged between 512 and 535 degrees fahr., a remarkably steady figure, being an average superheat of 158.0 degrees. At the engine receiver the range of temperature was from 475 to 505, an average superheat of 125.7, showing a loss of superheating in transmission of 32.2 degrees fahr. The ashes and unconsumed coal weighed back were 11.26 per cent. of the coal burned, a rather higher figure than anticipated. The coal burned per sq. ft. grate hr., 16.27 lb., was considerably lower

than is considered best for high efficiency. The low draft in this case does not warrant high rates of combustion, but 20 to 25 lb. would have given better results. Some shortening of grate surface would be economical if the present load and fuel were continued, but as greater loads and possibly inferior coals may sometimes be encountered, it is probably unwise to make any change. The evaporation in lb. of water per lb. coal, 7.45 actual and 8.93 equivalent, is very good. This was due not only to the excellent grade of coal used, but also to the design of the boiler and furnace, the superheater, the deflecting dampers and other essential details. As the superheater was treated as a part of the boiler, it became necessary in computing the factor of evaporation to take into consideration the total heat of superheated steam, which involves, of course, the much disputed question of its specific heat. The most complete and accessible data on this point were found in a paper by Mr. Geo. A. Orrok, member American Society Mechanical Engineers, published in *Power* for August, 1904. The efficiency of 71.9 per cent. secured on the combined boiler and superheater (based on an assumed calorific value of the fuel) is excellent, although slightly higher results have been secured under particularly favorable conditions. Had the boiler been running at 25 per cent. higher rating, and fired by a stoker of experience in making tests, and in getting the greatest possible work out of the fuel, a still better figure would undoubtedly have been reached.

It will be noticed that the work being done called for a boiler h. p. of only 94.4, which was but 93 per cent. of the boiler's rating.

*Steam Engine* (see Exhibit A). — It will be noticed that the vacuum was low, the range being from 21 to 23½ in., averaging 22.8. This is due, no doubt, in part to the high external air temperature, and also to some small leaks still existing in exhaust and condenser pipes, although these had been very carefully gone over. The reheating coil in intermediate receiver is supplied with superheated steam, and raises the temperature of the steam between high and low pressure cylinders 35 degrees. The speed of the engine averaged a little lower than that intended, 80 rev. per. min. The load was fairly well divided between high- and low-pressure cylinders, which balance will be brought still closer with increase of vacuum. The engine itself was slightly underloaded, and will give better results with 20 per cent. more work.

It is interesting to note the exact quantities of water con-

sumed and their disposition. The amount chargeable against the engine was,

| | | |
|---|---|---|
| From condenser.................................... | lb. | 18 212.14 |
| Drain from high-pressure exhaust to waste....... | lb. | 34.00 |
| Drain from grease extractor to waste............ | lb. | 468.29 |
| Total steam passing through engine............. | lb. | 18 714.43 |
| Add condensation in reheating coil............. | lb. | 652.00 |
| Total chargeable to engine................... | lb. | 19 366.43 |

The total water chargeable to boiler was,

| | | | |
|---|---|---|---|
| From condenser, as above....................... | | lb. | 18 212.14 |
| From reheater........................ | 652.00 lb. | | |
| From condensation in feed water heater (computed)........................ | 273.18 lb. | | |
| Balance made up from circulating system, | 8 321.20 lb. | | 9 246.38 |
| Total................................... | | lb. | 27 458.52 |

Eight thousand three hundred and twenty-one and two tenths lb. is the amount of water which would have to be purchased if the owners did not have a private supply, as would be the case in any large city taking its water from a city system of distribution.

Of the total make-up water, 9 246.38 lb., the following amounts are chargeable to the engine:

| | | |
|---|---|---|
| Drain from high-pressure exhaust................ | lb. | 34.00 |
| Drain from grease extractor...................... | lb. | 468.29 |
| Drain from reheater............................ | lb. | 652.00 |
| Total.................................... | lb. | 1 154.29 |

The remainder, 8 092.09 lb., is the amount properly chargeable to the expense of operating the auxiliaries, and to other miscellaneous leakages and losses.

The coal per i.h.p. hr. (2.43 lb.), which includes auxiliaries, is good. For the engine alone the coal per i.h.p. hr. is 1.71 lb. The water consumption per i.h.p. hr. of engine alone, 12.75 lb., is exceptionally gratifying, considering the low vacuum and the underloaded engine. This figure establishes a new record in this field, and is very creditable to the builders of the engine. The percentage of water used in the auxiliaries, 29.5, is high, although the figure includes, of course, all other incidental losses and leakages. These auxiliaries consist of the four pumps already referred to, which are of the single cylinder, throttling, non-condensing pattern, having water rates of undoubtedly

100 to 125 lb. per i.h.p. hr. It was thought that there wo ul be no material loss from this source as their exhausts were to be used for heating the feed water from the hot well temperature to the boiling point, 212. The desired temperature of feed seems to have been reached, and it is possible that some economy might be effected by turning one or more of the auxiliaries into the condenser.

Still further economy in fuel could, of course, be secured by driving these auxiliaries from the main engine, but as this would involve complicated and expensive construction in the way of pulleys, tighteners and variable speed devices, it was not thought desirable for a plant of this size and character.

*Circulating Water.* — An attempt was made to measure this water during the test, but this was found impracticable. After the close of the day's run, the discharge from the well pumps was turned into measuring tanks. The average speed of the small pump during the day had been 31 single-acting strokes per min., but on account of increased pressure through the hose, we were unable to run it above 25, at which speed its actual rate of discharge was 1 477 gal. per hr. Its displacement at this speed, allowing 5 per cent. for slip, was 1 623 gal. Had we been able to speed it to 31, it would have discharged at the rate of 1 831 gal.

The large pump was run and also tested at 17 strokes, at which speed it discharged at the rate of 3 241 gal. per hr., its displacement as above being 3 921. These figures show that either the pumps were not filling, or that they had excessive slips. When the two pumps were tested together they threw water at the rate of 4 800 gal. per hr. With higher steam pressures and lower discharge head, as in regular service, they would undoubtedly deliver the 5 200 gal. per hr. called for by the condensing of the amount of steam delivered by the engine. No accurate test of the capacity of these wells could be made, but it is believed that they will deliver as a maximum from 6 000 to 6 500 gal. per hr. The low temperature of this water, 58 to 60 the year round, makes it exceedingly valuable for condensing.

*Mill Output.* — As 17.77 bbl. of flour were made per hr. with the consumption of 368.5 lb. of coal, the amount per bbl. was 20.73. This also is an excellent figure and one which establishes a new record in plants of this kind in this part of the country, with ordinary Illinois coals. It should be remembered that this result was secured with an inexperienced fireman, a

low vacuum on engine, an underloaded boiler and engine, with some feed water heat being wasted, and with a plant not thoroughly warmed. The plant is shut down every night for 12 hr., and requires some time during the forenoon to get everything thoroughly warmed. The loss in efficiency due to shutting down is shown by the fact that the coal consumed per bbl. during the afternoon was 20.2 lb., although this included the cleaning of fires. The h.p. per bbl. of flour made per hr., 8.6, represents good practice.

### EXHIBIT A — RESULTS OF ENGINE TRIAL.

| | | |
|---|---|---|
| Date | | August 15, 1905 |
| Duration | | 10 hr. |
| **Dimensions of Cylinders:** | | |
| High-pressure cylinder, diameter | | 12 in. |
| Low-pressure cylinder, diameter | | 24 in. |
| Length of stroke | | 36 in. |
| Rated h.p. | | 175 |
| **Pressures (Gage):** | | |
| Steam at boiler | | 150.7 lb. |
| Steam at main receiver | | 148.5 lb. |
| Steam at intermediate receiver | | 18.7 lb. |
| Vacuum | | 22.8 in. |
| **Temperatures:** | | |
| External air | | 92.0 degrees fahr. |
| Indoor air | | 92.0 degrees fahr. |
| Steam in boiler | | 365.9 degrees fahr. |
| Steam leaving superheater | | 524.8 degrees fahr. |
| Steam at main receiver | | 490.6 degrees fahr. |
| Steam entering intermediate receiver | | 254.9 degrees fahr. |
| Steam leaving intermediate receiver | | 289.9 degrees fahr. |
| Water in hot well | | 117.2 degrees fahr. |
| Water in feed pipe | | 208.4 degrees fahr. |
| Circulating water entering condenser | | 60.0 degrees fahr. |
| Circulating water leaving condenser | | 102.6 degrees fahr. |
| **Superheat:** | | |
| Leaving superheater | 524.8—365.9 | 158.9 degrees fahr. |
| In main receiver | 490.6—364.9 | 125.7 degrees fahr. |
| Leaving intermediate receiver | 289.9—254.9 | 35.0 degrees fahr. |
| **Speed:** | | |
| Rev. per min., average | | 77.1 |
| Piston speed, ft. per min | | 462.6 |
| **Horse-Power (Indicated):** | | |
| High-pressure cylinder | 85.74 | 56.4 per cent. |
| Low-pressure cylinder | 66.19 | 43.6 per cent. |
| Total | 151.93 | 100.0 per cent. |
| Proportion i.h.p. is of rated capacity | | 86.8 per cent. |

COAL:

| | | |
|---|---|---|
| Rind | | Carterville washed |
| Size | | No. 1 (large nut) |
| Total consumption | | 3 685 lb. |
| Per i.h.p. per hr. | | 2.43 lb. |

WATER:

| | | |
|---|---|---|
| From condenser | 18 212.14 lb. | |
| From grease extractor | 468.29 lb. | |
| From h.p. exhaust | 34.00 lb. | |
| | 18 714.43 lb. | |
| From reheater coils | 652.00 lb. | |
| | | 19 366.43 lb. |
| Balance (to auxiliaries, leaks, etc.) | | 8 092.09 lb. |
| Total | | 27 458.52 lb. |
| Per i.h.p. hr. engine, alone | | 12.75 |
| Per i.h.p. hr., including auxiliaries | | 18.07 |
| Percentage of total water used in auxiliaries | | 29.5 |
| Approximate quantities of circulating water passing through condenser per hr. (computed) | | 5 180 gals. |

FLOUR OUTPUT:

| | |
|---|---|
| Bbl. of 196 lb. each, made during trial | 177.72 |
| Bbl. of 196 lb. each, made per hr. | 17.77 |
| Bbl. of 196 lb. each, made per 24 hr. | 426.48 |

HORSE-POWER:

| | |
|---|---|
| Per bbl. made, per hr. | 8.606 |
| Per bbl., made per 24 hr. | 0.3585 |

COAL CONSUMED:

| | |
|---|---|
| Per bbl. flour made | 20.73 lb. |

### EXHIBIT B — RESULTS OF BOILER TRIAL.

| | |
|---|---|
| DATE | August 15, 1905 |
| DURATION | 10 hr. |
| NUMBER OF BOILERS IN OPERATION | 1 |
| STATE OF WEATHER | Clear |

DIMENSIONS AND PROPORTIONS:

| | |
|---|---|
| Kind of boiler | Hor. return tubular |
| Dimensions of shell, diameter and length | 60 in. by 20 ft. |
| Number and diameter of tubes | 46-4 in. |
| Grate surface, upper, 5 ft. wide, 4½ ft. long. Area | 28.5 sq. ft. |
| Water heating surface | 1 231 sq. ft. |
| Superheating surface. Foster | |
| Percentage of air space in grate (upper) | 42.5 per cent. |
| Ratio of grate surface to water heating surface | 1 to 54.7 |
| Chimney dimensions, height and diameter | 30 in. by 100 ft. |

AVERAGE PRESSURES:

| | |
|---|---|
| Steam in boiler, by gage | 150.7 lb. |
| Steam in boiler, absolute | 165.4 lb. |
| Draft suction. Inches of water: | Uptake, 0.432; fire box, 0.211 |

AVERAGE TEMPERATURES:

Of external air ....................................92 degrees fahr.
Of boiler room ....................................92 degrees fahr.
Of escaping gases entering chimney ..............409.4 degrees fahr.
Of feed water entering boiler ....................208.4 degrees fahr.
Of steam in boiler..................................365.9 degrees fahr.
Of steam leaving superheater......................524.8 degrees fahr.

FUEL:

Kind of coal ................................ Hurricane washed
Size of coal ....................................No. 1 (large nut)
Cost per ton of 2 000 lb., delivered..........................$2.90
Calorific power by calorimeter. B.t.u. per lb., assumed....12 000
Theoretical evaporative power, from and at 212 degrees fahr. in lb. water, per lb. coal..........12.42 (assumed)
Total quantity consumed ..................................3 685 lb.
Total ash, clinkers, and unburned coal.......................415 lb.
Proportion of ash, etc., to coal...... ...........11.26 per cent.
Total combustible burned ..................................3 270 lb.

COMBUSTION PER HOUR:

Coal actually consumed ................ ....... .....368.5 lb.
Combustible actually consumed ..........................327.0 lb.
Per sq. ft. grate surface, coal...........................16.37 lb.
Per sq. ft. grate surface, combustible....................14.53 lb.
Per sq. ft heating surface, coal..........................0.300 lb.
Per sq. ft. heating surface, combustible...................0.266 lb.

CALORIMETRIC TESTS:

Quality of the steam (dry steam = 1)..........................100
Amount of water entrained in the steam..............0 per cent.
Amount of superheating, 524.8—365.9..........158.9 degrees fahr.

WATER:

Amount apparently evaporated..........................27 458 lb.
Amount actually evaporated ...........................27 458 lb.
Factor of evaporation (allowing for superheat)...............1.1986
Equivalent evaporation into dry steam from and at 212 degrees fahr. ...................................32 911 lb.

ECONOMIC EVAPORATION. Per lb. of coal:

Water actually evaporated..................................7.45 lb.
Equivalent from and at 212 degrees fahr..................8.93 lb.
Per lb. of combustible. Water actually evaporated .......8.39 lb.
Equivalent from and at 212 degrees fahr................10.07 lb.

EVAPORATION PER HR.:

Water actually evaporated ............................2 745.8 lb.
Equivalent from and at 212 degrees fahr..................3 291.1 lb.
Per sq. ft. heating surface. Water actually evaporated .. 2.23 lb.
Equivalent from and at 212 degrees fahr....................2.67 lb.
Per sq. ft. grate surface. Water actually evaporated....122.03 lb.
Equivalent from and at 212 degrees fahr.................146.3 lb.

EFFICIENCY:

Percentage of total calorific power utilized, or efficiency (on assumed B.t.u.) ...........................71.9 per cent.

Water evaporated for \$1.00 worth of fuel, actual.........5 140 lb.
Cost of evaporating 1 000 lb. of water (actual).........19.45 cents
Coal consumed per boiler h.p. per hr.......... .........3.86 lb.
Cost of same................................ 0.559 cents

HORSE-POWER:
Actually developed on basis of 34½ lb. water evaporated
per hr. from and at 212 degrees fahr.................95.4 h.p.
Commercial rating, at 12 sq. ft. heating surface ........102.6 h.p.
Proportion capacity developed is of commercial rating..93.0 per cent.
Heating surface required to develop 1 h.p...............12.9 sq. ft.

# SOME NOTES ON FUEL BRIQUETTING IN AMERICA.

By Clarence M. Barber, Member of the Civil Engineers' Club of Cleveland.

[Read before the Detroit Engineering Society, December 29, 1905.]

America has always been, and is now, favored above almost every country on the globe in the supply of fuel. In no other land is it so abundant, of so good a quality or so varied in kind.

Our extensive fields of bituminous and anthracite coal have been developed beyond those of any other country, and we have yet untouched great fields of baser fuel in the shape of lignite and peat, some of which are quite important on account of geographical location. The forests, once of first importance, are no longer a factor to be used in estimating the fuel resources of our country.

The annual supply of coal in this country has been increased enormously within the past decade. In 1895, it was 193 000 000 tons. Our production in 1904 was 352 000 000 tons and estimates indicate that 1905 statistics will show that we have mined over 1 000 000 tons per day. But the consumption has also increased beyond what any one could have reasonably anticipated.

That this wonderful production only just meets the constantly increasing demand is shown by the fact that the price to the consumer does not diminish, but rather tends to increase each year.

Of this great quantity, only about 21 per cent. is anthracite. To the remaining 79 per cent. is chargeable the dark gloom that hangs over so many of our homes and factories.

## Briquetted Fuel in Europe.

The American traveler in Europe notes with interest the use there of briquetted fuels. Coal briquettes are in large piles at the railroad coaling stations and are seen in use, more or less, everywhere, but especially in Germany, Austria-Hungary, Belgium, France and England.

Our United States consul-general, Frank Mason, in his reports states "that briquettes form the principal domestic

fuel of Berlin and of the cities and districts in Germany. They are used for locomotive and other steam firing and are employed for heating in various processes of manufacture. For all these uses they have three tangible advantages. They are clean, convenient to handle, light easily and quickly, and burn with a clear, intense flame. They make practically no smoke and are, with all, the cheapest form of fuel for most purposes."

At another point in his report Mr. Mason says: "Berlin, although a busy manufacturing city, ranks as one of the cleanest and best cities in Europe. One of the first things usually noticed by American and English travelers visiting the German capital for the first time, is the absence of that cloud of dusty smoke that overhangs so many towns and cities in our country."

Again Mr. Mason says: "If American municipalities, beyond the economic range of anthracite, are ever emancipated from their present vassalage to the smoke incubus, it will be through the enforced use of one or more of three forms of prepared fuel, viz.: coke and fuel gas made in closed ovens from bituminous coal, and briquettes made from lignite, peat and other inferior materials by processes which have been invented, tested and proven to be efficient by the older and more economical countries of Europe."

Recently, and especially within the last ten years, considerable advancement has been made in this country in the way of introducing coke and gas as domestic fuel in cities. Coke from by-product coke ovens has been so favorably received that the prospect for the more extended use of this cleaner fuel is very encouraging.

Fuel briquettes are not made, or in use, in this country, except to a very limited extent and only very recently. Mr. Robert Schorr, at San Francisco, has recently installed a successful plant. Some peat briquettes are successfully made in Canada. There are some other briquetting plants, but those that have come to our notice are yet in the experimental stage.

In Germany alone the annual production is 13 000 000 tons. France produces over 3 000 000 tons and other countries bring the world's production up to over 25 000 000 tons.

## Materials for Briquettes.

Briquetted coke breeze makes a very superior and clean fuel, and almost smokeless briquettes can also be made from anthracite culm and bituminous slack, as well as also from lignite and peat.

Fuel briquettes may be made from almost any combustible substance. Some materials, such as lignite and peat, can be formed into briquettes by pressure alone in a suitable press, but most materials require the addition of some adhesive substance as a binder. There is hardly a vegetable, animal or mineral carbonaceous material that can be thought of, that some one has not attempted to raise to a marketable value by briquetting, and, as usually the substance is a refuse, the financial gain, if it can be briquetted successfully, suggests at once an attractive investment for capital.

## Methods of Manufacture.

In general, it may be said that the materials that have been most successfully briquetted for fuel are bituminous slack, anthracite culm, coke breeze, lignite and peat. Each of these substances requires different treatment on account of its different properties. They cannot be worked in precisely the same manner.

Some materials require more or a different binder than others, or none. Generally the moisture must be reduced by drying, but lignite works well with 17 per cent. of moisture. Again, great or little pressure may be required, etc.

If we take as an example anthracite culm, the process of briquetting, without going sharply into detail, may be as follows: In the first place, to prepare for briquetting, part or all of the following operations may be necessary: Washing, drying, crushing or screening. The first is necessary if the ash is too high and the last is almost always necessary to prevent foreign substances from injuring the machinery.

The prepared culm is ready to be combined with the pitch, which has been previously cracked or crushed to 0.5 in. and under. It is also not unusual to add a third element, such as a small percentage of bituminous coking coal. The ingredients are proportioned by some form of a measuring device such as three screw conveyors, or better, a Trump measuring machine. The carefully predetermined proportions are accurately measured dry, and the mixture is now spouted to a disintegrator or mill, where it is reduced to the proper fineness and thoroughly blended. The pulverized material is now passed to what is called the kneader, where superheated steam melts the pitch and revolving blades stir the mixture which has now become a hot paste. It is next forced into molds, pressed and ejected therefrom, usually upon some form of a conveyor.

The hot briquettes become hard as the pitch cools and after a few minutes on the slowly moving conveyor they may be loaded into cars for shipment. There is a so-called wet process, which differs from the above only in the manner of introducing the pitch. The pulverized coal having been thoroughly dried, is heated and stirred by moving blades, while the melted pitch is mixed with it. The resulting paste is then molded as above.

There are many other processes, but those used for bituminous and anthracite coals or coke breeze differ from the above chiefly in the kind of binder or the type of press used.

### Binders.

Coal-tar pitch is used more extensively than any other binder; in fact, we understand that in Europe the market for coal-tar pitch is supported by the demand for that product in the manufacture of fuel briquettes.

Within the last few years the supply of pitch has been greatly augmented by that obtained from by-product coke ovens. This fact alone has given the briquetting industry in Europe great assistance, and the lower price of pitch from the same cause in this country is a new inducement for the development of the enterprise here.

Owing to the fact that the cost of pitch has been an important factor in the expense of producing briquettes, many other materials have been tested with varying results. Asphalt pitch is quite successfully used. Sago flour is used with a very small quantity of pitch by an English firm, with, it is claimed, a satisfactory result. A low grade of molasses obtained from sugar factories, and a mucilaginous liquor obtained from paper mills, have also been used. Rosin is used to some extent. Quite a number of inorganic substances are also on the list of binders. These contain more or less ash, and are, therefore, undesirable.

Practically all other binders have lost in importance in proportion as good coal-tar pitch has been reduced in price. It is acknowledged to be the best binder. Its points of advantage are chiefly: that it is a strong adhesive which sets quickly on cooling; that it contains practically no ash, so that the briquettes show rather less ash than the materials which it binds together; that it protects the briquettes against hygrometric changes, so that they will not suffer when exposed in wet or freezing weather; and further, that on account of its high calorific value, it increases the thermal units in the briquettes above that of the other ingredients.

Its points of disadvantages are its cost and the fact that when used in considerable quantity it causes a slight smoke when the fire is being started or when a fresh charge is added. The smoke is very thin and light and lasts but a few moments. It is reduced to a minimum when the quantity of pitch is small, and if the furnace has a suitable draft it may not be observable at all.

## Pitch.

Coal-tar pitch, as all doubtless know, is obtained from coal tar by distilling off part of the volatile oils. The pitch may be soft or hard according to the amount of the volatile oils remaining when the distillation is stopped. If continued until all the volatile oil is removed, then there will remain simply a dry fixed carbon or coke. The value of pitch as a binder for the manufacture of the briquettes depends chiefly upon the proportions of oil and fixed carbon the specimen contains. This point was established by a careful series of tests made at the Coal Testing Plant of the United States Geological Survey at the Louisiana Purchase Exposition.

The softer specimens of pitch, such as those used for pavements, melting at about 25 degrees cent. and the roofing pitch melting at 38 degrees cent., must be shipped in barrels, as they often flow like wax at summer heat or from the heat absorbed from direct sunlight even in cool weather. The harder specimens, or those which melt above about 55 degrees cent., can be handled in bulk or in sacks, and do not require barrels if kept shaded from the sun. This matter is quite important as an element of the cost of pitch. A saving of between $2.00 and $3.00 per ton is effected if the pitch does not require to be shipped in barrels.

Both soft and hard pitch are used for the manufacture of briquettes, but we note that most European manufacturers are using rather hard pitch.

## Briquetting Presses.

That part of the machinery of a briquetting plant which is used for handling the material, crushing, screening, elevating into bins, measuring and mixing the ingredients, etc., is all such as may be seen at work elsewhere in this country. The press used for briquetting, while it is often very similar to our brick-making machines, is really the only special machine required. It is also the most expensive and important. The

press must be adapted to the kind of material to be worked, to the size and shape of the briquettes desired, as well as to the quantity to be produced in a unit of time.

In Europe, where the industry has been developing for the last forty years and more, the press question has been pretty well exploited, if we may judge from the number of different kinds of presses that are in use and offered for sale by manufacturers.

In general, the presses are divided into classes according to their mechanical design. I will note a few of the more important classes.

### Open-Mold Presses.

Open-mold presses are those in which the material is forced through a tube-shaped mold by a reciprocating plunger or a screw. The continuous column delivered from the tubular mold is usually cut by wires to the desired length of the briquettes. Sometimes the reciprocating plunger produces a briquette at every stroke, each being formed against the preceding one, the tube being long enough to contain several briquettes. In this case the column issuing from the mold being composed of separate briquettes does not require to be wire cut, as the briquettes fall apart as they issue from the mold. The resistance against which the plunger or screw acts in this case is the friction of the material against the sides of the mold. Open-mold presses are used in this country for wire-cut brick, and those of the reciprocating plunger kind are worked not far from Detroit on peat, for which they are well adapted. It is evident that the consistency of the material used in these presses must be carefully gaged, as the density of the briquettes and the pressure will depend on the viscosity of the material fed to the press.

### Closed-Mold Presses.

Of these there are a large number. There are single-plunger presses, in which the material is filled into a mold and pressed by a single plunger against a solid resistance, which may be a plate covering the opposite end of the mold. This press is successfully worked on lignite, but it is not generally adopted for other coal.

The double-plunger press is simply a mold with a pair of opposing plungers. In this press the material receives pressure on both ends at once. Where heavy pressures are required, and especially on large briquettes, foreign engineers recommend this press.

Most of the larger briquette factories of Europe use some form of the double-plunger press. In the Couffinhal type, which is one of the most successful in use, there is a large disk, usually about 54 in. in diameter and about 5 in. thick. This disk revolves in a horizontal plane. The molds, usually 8 in number, are simply holes cut through the disk. The material is filled into the molds and receives pressure from below and above at the same time by a pair of vertical plungers which usually give a pressure of about 2 000 lb. per sq. in. After each stroke and when the plungers are withdrawn, the disk revolves far enough to bring another mold under the plungers, and the already pressed briquette is moved under an ejecting plunger and forced out upon a conveyor. Presses of this type, working on large briquettes, produce as high as 15 tons or over per hr. When working on small briquettes the production falls as low as 2 tons per hr. and under.

Another type of the closed-mold press is that which has been known as the eggette press of Belgium. This machine has two tangent cylinders whose axes are parallel. The cylinders roll together and the eggettes are formed in the semi-egg-shaped depressions which cover the surfaces of the cylinders.

This eggette machine is quite largely used. It has the advantage of yielding a rather large production, usually about 5 tons per hr. Its disadvantages are, that it requires more power than almost any other machine; it is difficult to keep in good running order and it is necessary to adjust the mixture of material to suit the machine rather than for any other conditions. Furthermore, there is more or less material wasted.

### Size of Briquettes.

It may be noted that the machines producing the larger briquettes usually yield them at a somewhat lower cost than those producing the smaller sizes. This accounts for the fact that some consumers break up the larger briquettes for domestic use. In America, however, the domestic trade demands small briquettes. There seems to be a tendency also in Europe at present toward the smaller sizes.

For shipment and use in steamboats, where economy of space is of the first consideration, large rectangular briquettes are used because of the quantity that can be piled in a given space. A common briquette in France for this purpose is one weighing 10 kg. or 22 lb. Briquettes measuring 7 in. by 4 in. by 4.75 in., and weighing 2 kg., 500 g. or 5.5 lb. are now used for

ocean shipment and also for locomotive use. Rectangular briquettes from these sizes down to less than 1 lb. each, and eggettes weighing a few ounces, are common for domestic use.

Briquettes of every conceivable solid figure have been made.

It is important to note that good briquettes may be stored out of doors for years without suffering any deterioration. Spontaneous combustion in large piles is said to be impossible.

So important are the considerations of economy of space and safety of storage, together with some other advantages, that we are told the very best coal is sometimes ground up and briquetted for the bunkers of steamships.

### Conclusion.

In the matter of introducing the briquetting of fuel into this country, it is but natural to regard it as simply a transplanting of a foreign industry from European into American soil, but it seems to be much more than this. Quite a number of attempts at starting the industry here have failed. The writer examined, quite carefully, into the causes of some of these failures and obtained some valuable information.

In regard to cost of manufacture we note that Mr. Robert Schorr, of San Francisco, in his valuable paper in the *Transactions of the American Institute of Mining Engineers*, February, 1904, gives the cost per ton of briquettes in western America, as follows:

| | |
|---|---|
| Labor, exclusive of stacking | $0.16 |
| Oil and grease | .006 |
| Sundry stores | .01 |
| Steam fuel | .04 |
| Interest and depreciation | .05 |
| Total | $0.266 |

The total of these figures coincides so closely with the writer's own estimates that we believe them to be sufficiently correct for approximate estimates near any large city.

In regard to the cost of pitch we have not been able to obtain close figures, but we believe this item may be estimated for the eastern or middle states at about $7.50 per ton, or an 8 per cent. mixture would give for the briquettes per ton $0.60. This gives a total, exclusive of the cost of anthracite culm, slack coal or coke breeze; of $0.87 per ton of briquettes.

If the cost of anthracite culm, for example, is taken at $0.50 per ton, and 67 per cent. is used, this item would give $0.33 per ton of briquettes. If also we add to this 25 per cent of slack coal

at $1.60 per ton, we should have for this item $0.40. This would give a grand total for the cost of anthracite briquettes $1.60 per ton.

In regard to the selling price of briquettes there are no figures at hand for this country. It is estimated, however, that they will command a price between the best bituminous and anthracite coals.

In regard to the proper location for a briquette plant, of course, this depends on the location of a supply of the material to be used and of the market. At the anthracite mines there is sufficient culm to last several briquetting factories many years and the market of the large eastern cities is near.

Many other places there are where, on account of coke plants and large coal distributing points, coke breeze and slack coal are to be had. Some of these places are at long distances from the mines and have an advantage on freight for a higher selling price. Lignite and peat are important sources for the future briquetting industry in America.

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## SUBTERRANEAN WATER SUPPLY.

BY JOHN RICHARDS, MEMBER OF THE TECHNICAL SOCIETY OF THE PACIFIC COAST.

[Read before the Engineering Congress (Lewis and Clark Exposition), at Portland, Ore., June 29, 1905.]

THE brief monograph to be read, if it be long enough to require explanation, will differ from papers such as are usually presented on occasions of this kind, in that the author is almost wholly unacquainted with the subject treated. This should have notice at the beginning.

There is scarce a subject connected with engineering science or the arts that has escaped modern investigation, especially in those branches that affect the social and economical conditions of population, but in some recent experience I have encountered problems that indicate an omission that very nearly affects a large part of the population on this coast, especially in California, — the subject of subterranean water supply.

Of course we must recognize the subject as one surrounded by peculiar and obscure circumstances, completely removed from observation, and resting, as it always must, largely on conjecture and the limits of exploration by boring. Still, there is a good deal that can be deduced from geological and other premises, experience and observation that would be of value if systematized, arranged and made available to those who desire to discover and procure water in this manner.

The erosion of the steep volcanic hills and mountains in California has carried down into the valleys extended beds of

gravel, some of it worn and mixed with sand, some of it in the form of crushed or disintegrated stone that contains 40 per cent. or more of pure water and is disposed at various depths from 20 to 200 ft. below the surface. Ten ft. is named as a minimum for pure water, because close or compact strata of that depth will insure sufficient filtration to remove deleterious matter.

The water is in some cases flowing at a rate dependent upon the coarseness and compactness of the gravel, 3 to 10 ft. an hour; in other cases is impounded and static, like lakes on the surface. The latter is by all means the most desirable source for water, because the area of infiltration into wells or pits is as their whole exposed perimeter, while in the case of intercepted or flowing water, the area of infiltration from one direction, and after saturation is exhausted, is not more than one third as much, however great the general supply may be.

These gravel strata are disposed with but little respect to present surface indications, in their immediate vicinity at least, and deviate in an extraordinary manner as to thickness, the number of strata and their depth, so that no area of any extent can be predicated on wells, except by boring them near together.

In some cases the water level rises and falls 20 ft. or more with the seasons; in other cases from a like depth rises above the surface, forming what are called artesian districts of considerable area. As before remarked, the extent of these water-bearing gravel deposits does not seem to bear any particular relation to the present physical conditions of surface, except that they are fluvial and in the bottoms of valleys; not always, perhaps, because one of the most copious supplies I have met with, near San Jose, is at a depth of only 40 ft. from the surface, but at an elevation of 90 ft. above the general level of the pumping districts around that city.

Twenty years ago I had my attention drawn to the copious supply of water contained in the gravel strata around the south end of San Francisco Bay, and constructed, as I believe, the first successful centrifugal stage-pumping machinery to raise this water for irrigating purposes. From 100 to 300 gal. per min. could be drawn from a single tube well, or 500 gal. from two or three adjacent wells, and the supply seemed inexhaustible, even when the pumping stations were situated near together.

To afford a sufficient supply, the well tubes had to traverse an aggregate of 8 to 10 ft. of gravel strata, found usually 100 ft.

or more below the surface, the machinery being set 40 to 80 ft. from the top, or within suction distance of the water level. The data acquired, except as to adaptation of the pumping machinery, were meager. There were no circumstances to determine the rate of horizontal flow or the amount of percolation for a given area, no indication of the source of water, which might have been from precipitation on the hills or higher lands, by infiltration from the bay or general percolation over the surface of the valley.

I will digress to say that water from gravel strata should be raised by centrifugal pumps whenever the quantity is sufficient to permit a constant pumping volume. These pumps made for the required pressure are economical and not injured by sand, which is always present in such water when raised rapidly.

Centrifugal pumps that have their impellers inherently balanced and no running joints to maintain against water pressure have no metallic contacts, no valves and are very durable. When the thrust on the impellers is compensated by disks or other contrivances, such pumps are perishable and soon circulate instead of discharging water.

One point in respect to subterranean water deserves especial remark — the character of the water procured from underground sources. Respecting this, there is a widespread or even general belief that such water is impure, and, if we accept common facts, this may be conceded, but I will venture the statement that not one well in fifty is protected from surface infiltration, not even tube wells, and under these circumstances the water must be contaminated.

On the contrary, wells sealed against surface infiltration supply pure water, and when it is drawn from gravel, it is in every way, except aëration, preferable to impounded surface water. It is, in fact, filtered water held in a state of purity, preserved by natural means far more complete than any that can be artificially devised.

Having recently become a member of a water purveying company that proposes to procure a subterranean supply in a valley near San Francisco, I naturally cast about for information respecting gravel deposits, wells, surface infiltration, the permanence of general infiltration or supply, the relation of such water supply to overlying lands; also the extent to which such gravel deposits are indicated by the geographical environment and the trend of rock ledges that determines underground flow.

The paucity of the information obtainable led me to believe

that a short paper read here would direct attention to this subject and cause observance and collation of data by engineers interested in procuring and purveying water.

My own professional experience, outside of the few facts mentioned, has been confined to raising and impelling water, an art that, while it is far from perfected, is falling more and more within the field of computed results and standard machinery, especially on the Pacific coast, where I am proud to claim our engineers have a foremost place, taught them by various peculiar circumstances, including extreme heads and pressures that have no precedent in any other parts of the world.

I have mentioned my connection with stage centrifugal pumping on this coast, and as a matter of interest to the congress, and with permission of the Chair, I will supplement the foregoing remarks with a statement made and attested in 1902, respecting what I believe to be the first application of this stage method to actual commercial use, in this or other country.

This statement, prepared for use in interference proceedings in the United States Patent Office, is as follows:

## The Development of High-Pressure Centrifugal Pumps on the Pacific Coast.

It is common opinion throughout the Eastern states that centrifugal pumping has reached a more advanced stage on this coast than in other parts of this country, and this is certainly true in respect to many, if not most, of the varied uses to which these machines are applied, especially as to an early use of the high-pressure type that is now engaging especial attention in all countries.

The writer has been several times requested to explain this matter and give some of the facts relating to this "evolution," especially in respect to what are called high-pressure centrifugal pumps. This I cheerfully do, because the principal facts and data are at this time ascertainable, and in a few years will be lost, as is common in such cases; also for the reason that some legal proceedings now being conducted in the East involve the origin and progress of these pumps in this country.

Down to 1880 there had not been any regular manufacture of centrifugal pumping apparatus on this coast. A great many of a cheap kind were imported here to replace reciprocating pumps for irrigating purposes, because the water, when drawn from the gravel strata, was filled with sand and fine

gravel that soon cut away packing and destroyed sliding joints of any kind exposed to the water.

It was soon discovered that centrifugal pumps had no sliding contacts, no valves and were not affected by the sand and gravel, and besides, could be employed for large quantities of water. This and other reasons led to a manufacture of such machines here, the circumstances being as follows:

In 1880, the writer, then a director and manager of the San Francisco Tool Company of this city, was called upon to examine a pumping plant employed to drain one of the San Joaquin Islands, near Stockton, that belonged to some of the shareholders of the San Francisco Tool Company.

The machines in use were found to be very imperfect, and the writer recommended that a new and better pump be procured from one of the Gwynne firms, at London, with whose work he was familiar. There was no time for this, however, and he undertook the construction of a cheap centrifugal pump, which, with a new steam engine, removed the water and at the same time reduced the coal consumption from 4 500 lb. to 1 800 lb. per day.

This circumstance led to a contract with the city of Sacramento for a vertical draining pump to clear the surface water at the southeast end of the city; and this again to other pumps, especially for irrigating purposes, until a regular business was established, the San Francisco Tool Company being then sole makers on this coast.

Up to 1883 it was a common belief, even yet entertained by many people, that centrifugal pumps cannot be operated against a head exceeding 40 ft.; but in October of that year Dr. Chapin, who held the position of state entomologist in California, called at the works to ascertain whether he could not procure a series of such pumps to raise water 83 ft. on his ranch near Santa Clara, Cal.

I had little faith then, and now, in series pumps operating at different levels, and proceeded to design a pump, as shown in Fig. 1, in which the water passed consecutively through two impellers without being diverted from its plane of revolution normal to the axis.

Working drawings and a pump were made from this sketch, and the pump was started at the Tool Company's works in Stevenson Street, by Mr. A. F. L. Bell, now of this city, first as a single pump, with one impeller left out.

The pressure attained at the speed arranged was 30 lb.

per in. The second impeller was then put in and the pressure rose to double, or 60 lb. per in., and a telegram was sent to Dr. Chapin saying the company would contract for a pump to operate at a head of 85 ft.

This pump was made and erected in February or March of 1884 by Mr. C. H. Gorr of San José, and was perhaps the first stage-centrifugal pump set in practical operation in this country, having the distinct features of present practice, including the division plate and return passages between the impellers.

This pump attracted the attention of Mr. Henry Booksin of San José, a prominent fruit grower there, and a mechanic, with whom a contract was made to construct a two-stage pump

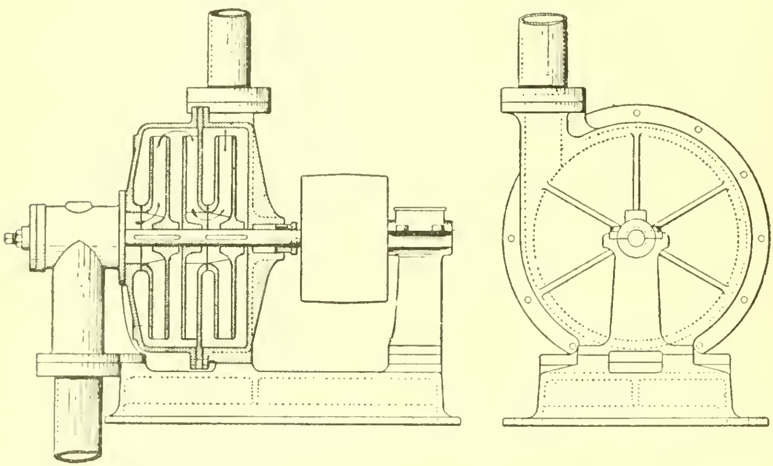

Fig. 1.

to operate against 90 ft. of head and raise 750 gal. per min. This pump is shown in Fig. 2, and it is to be questioned if there has ever been another made with more precision or more care in workmanship.

The work done by the San Francisco Tool Company was at that time of a very high grade, mostly on machine tools, and the pump was as well made as an iron lathe or planing machine. It was erected in a narrow pit, 80 ft. below the surface, in a fixed position, and the season being a very dry one, the water rose over the pump and there remained for *ten years or more*, the pump running each year from two to three months, night and day, raising sometimes at the rate of 1 000 gal. per min., and

received during this time no repairs whatever, not even examinations, being submerged and inaccessible.

This is an example of endurance that proves the advantage of good work and strong proportions, but is by any standard a strange result. In 1898, after fourteen years of service, this pump was dismantled and raised to the light again. All the bolts and attachments had to be cut away because of corrosion, but the main parts were preserved by Mr. Louis Booksin until the present month, and have been purchased by the Turbine

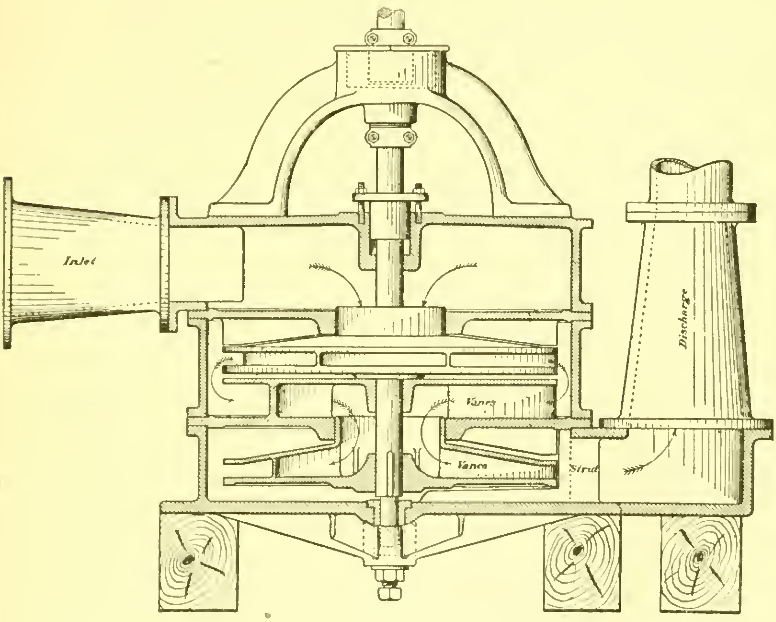


FIG. 2.

Pump Company, of New York, as a memento of early practice in stage pumping. The drawing, Fig. 2, was made from these parts.

In 1885 I went to Europe and made there some investigation and inquiry respecting centrifugal pumping, but found no stage pumps were in use at that time, and it is a fair inference that the pumps above referred to were the first to be practically and continuously operated.

With the exception of some special pumps designed between 1885 and 1900, I gave no special attention to centrifugal pumps until the advent of the stage pumps of Messrs. Sulzer

Brothers, of Switzerland, who produced a refinement in such machines by a purely scientific treatment or, as we may say, of "kinetic" construction that differed in respect to water ducts of careful proportions, a great increase in the rate of rotation and in the diffusion of water from the impellers that converted the energy of rotation into pressure.

This was an important advance; one that called for accurate and intricate workmanship, that, however easy it might be in this famous works, was not attainable in common shops. In that year I set about an attempt to balance the impellers of stage pumps, to simplify and cheapen their construction; also to attain an equal pressure on the sides of the impellers to prevent circulating leakage.

After several years of experiment, these things have been accomplished in such degree that a new type of high-pressure pumps will soon be so far perfected that their construction can be submitted to the world through the usual channels.

Engineering effort in this direction on the Pacific Coast is to a great extent a sequence of the extended use of water-raising and impelling machinery demanded by the physical circumstances of the country and its industries.

# THE PRINCIPLES GOVERNING THE VALUATION FOR RATE-FIXING PURPOSES OF WATER WORKS UNDER PRIVATE OWNERSHIP.

By Arthur L. Adams, Member of the Technical Society of the Pacific Coast.

[Read before the Pacific Coast Engineering Congress (Lewis and Clark Exposition), at Portland, Ore., June 29, 1905.]

## Purpose and Scope of Paper.

The constantly increasing interest among the thinking people of this country in the evolution of some process by which so-called "public service corporations" may be brought under such government control as will secure protection to the public against unfair discrimination, insure the making of no greater average charges for the service rendered than such service is reasonably worth, and at the same time afford such properties immunity from spoliation under the guise of lawful regulation, is justification for the careful consideration of any important aspect of this very difficult problem.

That many of the questions involved are of a character calling for solution by those familiar with works construction and management, and that the aid of such men is frequently sought to assist the courts in reaching right conclusions in cases arising under existing laws, fully warrants, in the opinion of the writer, this presentation.

Legislation on the subject may as yet be regarded as in an experimental stage, and the resulting accumulation of experience has demonstrated the unwisdom of many of the methods employed in attempts to establish such control.

The whole subject needs most careful consideration by those whose training best fits them to devise methods with a clear vision as to their practical consequences.

The regulation of rates by governmental agency, whether such regulation takes the form of the fixing of rates outright or the revision of rates made by the corporation, presupposes the right of the corporation to receive a fair and just return upon the value of its property.

The ascertainment of what constitutes the fair and equitable value of such properties is always the important initial

step. It gives rise to most interesting and complex questions involving the consideration of ways, means and cost of construction; of the subsequent practical conduct of such works as to their operation, maintenance, growth and financial management, and the value to the public of the service rendered. It also calls for the exercise of the judicial temper, a keen sense of justice and fair dealing, and often no small measure of imperviousness to public criticism.

The first before-mentioned requirements are certainly such as must be possessed by any successful engineer of high professional standing; and impartiality, discriminating judgment and equanimity under trying conditions should certainly characterize the members of a profession so often called upon to decide between contending interests.

It is, therefore, the writer's belief that our profession will fail of its privileges and its duty if it does not influence in a very large degree the final formulation of wise legislation on this subject, and sound court interpretations.

The principles governing the determination of value of all such properties are quite similar; and though this paper deals with but one class, as its title indicates, the writer hopes it may prove of interest to specialists in other lines.

No effort will be made to treat the subject of appraisement even of water works in all its aspects, but rather to assume conditions likely to prevail in bringing most public service corporations under governmental control or supervision as to rates.

By the adoption of certain premises it is intended that all exceptional cases arising from special contracts, special legislation, or otherwise, shall be turned aside and the question become a general one as to what, under the more ordinary circumstances, constitutes the just and reasonable value of water-works properties of private corporations devoted to and being used for the public convenience. And even when thus restricted, the limitations of space will confine the writer to the discussion of the leading principles and factors only.

It is therefore presupposed:

*First*, that works have been built under legal authority imposing no restraints affecting their value.

*Second*, that the value of the property is sought as the basis for the fixing of such rates by governmental authority as shall return to the owners a fair and just compensation for the service which is rendered.

### Fundamental Factors Influencing Value.

The question of what constitutes reasonable and just value under the above conditions ordinarily necessitates the consideration of the following questions:

(1) Is the plant of such character as to enable it to properly fulfill the obligations assumed of supplying the public with a suitable water service, both present and future?

(2) What has been the cost of the works?

(3) Has its acquisition been characterized by the exercise of a reasonable degree of prudence and engineering skill?

(4) Has the policy of the rate-fixing or other legislative authorities been such as to make necessary any special financial policy in the conduct or acquisition of the water-works properties, with special reference, —

*First*, to the refunding of capital invested in structures of perishable character, or having a usefulness limited as to time.

*Second*, to the allowing of interest returns upon the properties acquired for the future use of an increasing population.

(5) Would a reduplication of the existing structural works cost less or more than the present structural works have cost?

(6) Would the construction of substitutional works cost less or more than the present works have cost?

(7) Have the real estate and water-producing properties of the company increased in value?

(8) Has the franchise any value?

(9) Does any special value attach to the fact that the company has an established business capable of producing an adequate revenue?

(10) Does the value of the service rendered to the consumers limit the value of the property?

No single formula can be made sufficient for the determination of value in all cases. Each of the above enumerated factors and possibly others may, under certain circumstances, properly exercise an influence in determining the final result. The degree of weight which attaches to each may vary greatly with circumstances. No final conclusion can be intelligently reached until all have been considered and their relative importance weighed, often one against the other.

Value is, therefore, not a quantity which can be determined with any mathematical accuracy. Its limitations as to maximum and minimum can usually be fairly well defined.

When circumstances require the naming of a specific figure, it can only be reached by the final, possibly arbitrary, exercise of personal discretion after reasoning processes have so far as possible narrowed the field of its final employment.

The application of the result, however, in determining rates is of itself subject to no absolutely defined rule and admits of a considerable range of use without doing violence to natural standards of fairness and equity.

That value, therefore, cannot be determined with mathematical nicety does not detract from the usefulness of an appraisal, though it be in a sense approximate only.

The before enumerated fundamental queries will now be taken up in their order for the purpose of showing their relation to reasonable value and to some extent the manner of their application. These factors are so closely interrelated that it requires careful analysis to make clear their bearings, the one toward the other, and the limitations which each imposes upon the result sought.

### The Fitness of the Plant to Fulfill the Obligation which the Company has Assumed of Supplying the Public with a Suitable Water Service, both Present and Future.

The relations between the public and the water company are of a mutual character. If the public owes the company a sufficient revenue to operate and maintain its plant and pay to its owners a reasonable return upon its value, no less does the company owe to the public an abundant and uninterrupted supply of good potable water. It owes the exercise of such energy, prudence, skill, economy and capital as will successfully anticipate contingencies of accident or increased demand, and such as will at all times enable it to supply water at the least cost to the consumer consistent with justice to its stockholders.

Fair treatment and a fair valuation on one side presupposes the maintenance of an efficient and economical service on the other, and the *vice versa* is equally true. It is, therefore, proper that inquiry be made into the character of the plant used and intended for supplying water. Such an inquiry, particularly in regions of lesser rainfall, naturally falls into the following order:

(1) The water supply as already developed, as to quantity and quality.

(2) The adequacy and suitability of the provision for future increase.

(3) The present consumption and possible future demand.

(4) The suitability of the works for conveyance and distribution.

The scope and character of the investigations necessary to develop the desired information embraced under these various heads will, of course, differ greatly in different cases. With but one exception they call for no comment here. The appropriateness of each subject in determining value would seem to be beyond question. The second has, however, been called in question and claims attention. It has been contended often, and even so held by certain courts, that in determining value, only properties actually employed for the delivery of water or maintenance of the service at the time in question should be included. In view of this sentiment, it is well, therefore, to remember that the duty of a water company to maintain an efficient service implies and imposes the responsibility for anticipating the future increase of consumption, that the available supply may never for one moment fall below the proper and legitimate demand.

This responsibility in the supplying of a city means the forecasting, often for many years, of the probable population and per capita consumption.

It often means the necessity for the acquisition of necessary lands, water rights and storage reservoirs years in advance of their actual use for the delivery of water, lest when imperatively needed they be impossible of acquirement or are purchasable only at a prohibitive price.

The building of structures of the magnitude often required is in itself not infrequently a work of several years.

It therefore follows that at all times the water company must know in advance just where and in what quantities its future water supplies are to be secured.

The relation of such acquisition to present value will more appropriately be taken up under a later head.

## The Cost of the Works and Its Relation to Value.

Cost alone is seldom determinative of the value of any enterprise. Such value may be very materially influenced by the worth of business, that is, the amount of its earning capacity, present and prospective; or by the probable cost of building

a new plant of equal or better efficiency, or by other considerations.

But in the case of a system of water works devoted to public use at a rate of compensation fixed, not by its owners, but by governmental agency, and so fixed as to yield as a net return a moderate rate of interest only on the value of the property employed, the reasonable actual cost of such properties to their owners would seem to represent in almost all cases the lowest value upon which a rate schedule can with any claim to equity be based; and though said cost may be by no means determinative of full value, it may be regarded as the most important factor involved and the one usually determinative of the minimum of value.

Reasons for this view are simple, direct and conclusive because founded on the practical necessities of water-works construction, operation and financial management. They may be enumerated as follows:

*First.*— The purveying of water in a modern city is a necessity, upon which the welfare and very existence of the community depend. This service must, therefore, for the public good be performed by either private or public initiative, regardless of how great may be the necessary cost.

*Second.*— When rates are so fixed as to cover only the expense of maintaining the plant in a serviceable condition and pay a current rate of interest on the value of the property, such a policy precludes the company's making any financial provision for safeguarding its investments against depreciation by subsequent reductions in the market price of materials and labor, or otherwise.

*Third.*— Water-works properties of magnitude are never created at one time. They are the product of years of growth, being increased and extended a little at a time from year to year in compliance with the demands of the community growth. In many western states water service must largely precede instead of follow population, while the supply must always be maintained in quantity well in advance of present demand.

*Fourth.*— The imagining of a system created as of one time at current prices of lands, materials and labor, is wholly fanciful and has never supplied a large city with water, though such an assumption, as we shall see, at times has its use.

*Fifth.*— The final test of accuracy in every estimate is the actual cost of the completed work, built as such works are of necessity actually built. Actual cost of the completed work

must, therefore, be entitled to far greater weight in determining their value than any mere estimate resulting from the unavoidable assumption of impossible or unnatural conditions, and the use of assumptions in lieu of the results of accomplished fact.

*Sixth.*— Materials and labor once purchased and used as a part of a system of water works are no longer commodities in the market with value fixed by the rise and fall in prices of new materials and labor. At a certain cost these things have already entered into the creation of a system and are devoted to a fixed and permanent use; and why should one adopt as a starting point in the determination of structural values a standard subject to daily and almost unaccountable market variations in preference to a standard that actual accomplishment has unalterably fixed? There appears no good reason for so doing so long as the statements of actual cost are worthy of credence and their reasonableness unimpeached.

If, on the other hand, the rate-fixing powers have made such liberal provision in the revenue as to permit in addition to adequate returns upon the property value the making of ample provision for safeguarding the property against loss through falling prices of materials and labor, or the deterioration of perishable materials, or the abandonments incident to changing conditions, as well as other possible causes of loss, then cost becomes of lesser importance in determining a just value of all structural works, and corresponding greater weight may attach to estimated cost of works of duplication or substitutional equivalent without working injustice.

In determining the actual cost to a company of its plant, recourse can usually be had to its book record. The reliability of such record can by a competent engineer generally be determined by a study of the property. Not with exactness, of course, but within such reasonable limits as is worth while attempting in arriving at a final determination of present value, involving, as it does, so many broad considerations.

An important question, however, relates to the disposition of losses early in the history of the plant, arising from a lack of revenue, and their relation to cost and value.

The correctness of the policy of adding annual deficiencies in the operating of a plant to investment in determining the cost of a property to its stockholders as contrasted with other forms of investment paying current rates of interest is, of course, admissible. That such a course throws any light upon the

question of value of the property is not so clear and needs amplification.

In ordinary competitive enterprises such a computation would indicate nothing more than the loss which had been sustained in comparison with more remunerative forms of investment. If, however, as in the case of almost all water works, the enterprise be of a character which does not usually and therefore is not expected to yield adequate returns for some years after its inception, making the anticipation of this condition necessary to the successful financing of the enterprise and its establishment on a firm basis, such early losses may be charged to investment and become a measure of the money value of that intangible though none the less real asset known as "established business," or quality of being a "going concern," or possessing the ability to earn an adequate revenue, which the courts have recognized in certain important cases.

With a meritorious enterprise there should, of course, come a time in a reasonable period when the earnings become sufficient to pay a proper return upon the investment inclusive of such early losses, otherwise it must be classed as unprofitable, and its value be less than its cost.

In the case of a public utility limited as to its possible earnings by an extraneous rate-fixing body unnecessarily to a sum less than sufficient to constitute a proper return upon the investment, it would appear that redress from this condition should be sought in the courts rather than by charging such losses to investment for a long period of years.

Save in so far, therefore, as these losses may be said to be a measure of the cost of establishing the business, they do not of themselves, unsupported by other considerations, constitute a basis of value, and the most that can be claimed for them on their own account is that such losses from lack of revenue during the early history constitute the cost of and are therefore a measure of the value of that asset known as "established business."

Losses of capital in abandoned structures because of lack of sufficient revenue for refunding the money thus invested must be regarded as in much the same position as losses from inadequate interest returns from the same cause.

Such losses will, however, seldom accrue to the cost of establishing the business, for this should ordinarily be accomplished within the life of all structures of importance.

It is true that failure on the part of rate-fixing powers to

afford this revenue when it could reasonably be allowed without imposing excessive rates does a gross injustice to a water company, which should not be tolerated, but if such structures are permitted to long pass out of use without enforcing compensation for them, they cannot be said to still have value save possibly as a moral claim.

### The Degree of Prudence and Engineering Skill Exercised in the Acquisition of the Water-Works Property and Their Relation to Value.

In considering this subject it is necessary to ascertain:

*First*, whether no greater price has been paid for land and water rights than was reasonably necessary.

*Second*, whether the structural works have been designed and built on sound engineering lines and with a proper regard for a wise economy.

The first calls for no special comment.

In passing on the second it must be remembered that no small part of engineering is the adapting of means to ends, that there are almost no established standards of design, that no two men will ever plan works along identical lines, and that a wide range of liberty of choice must be accorded the engineer.

The appraiser has a right to expect and demand that the works shall have proven reasonably successful, considering all the conditions which have influenced or controlled their design and construction, with average practice as his standard rather than his own personal preference. Beyond this he should be sparing of criticism. Unqualified failures due to inexcusable ignorance or bad judgment must lead to rejection in determining value, but the appraiser will often find difficulty in determining in his own mind where to draw the line between what is excusable and what inexcusable. If he is a man of wide experience he is least likely to indulge in hasty or harsh condemnations, realizing that engineering is very far from being an exact science; that to some extent it will always be the unexpected that happens; that defects are more easily discoverable under the test of actual trial, and that criticism is far easier than creation.

The Past Policy of the Rate-Fixing Authorities in Making Provision for the Refunding of Capital Invested in Structures of Perishable Character or Having a Usefulness Limited as to Time, and in the Allowing of Interest Returns on Property Acquired for the Future Use of an Increasing Population, and the Relation of such Policies to Equitable Value.

Depreciation as ordinarily applied to water works results either from the wear and tear incident to use and exposure to the elements, or from enforced abandonment on the score of economy or of changed conditions.

For example of the first, iron pipes are gradually rendered useless by corrosion until renewal becomes necessary; for example of the second, pumping stations may have to be abandoned because the water supply has become of uncertain purity, or because increased consumption or later and better designed machinery renders the old unsatisfactory on the score of economy, even though such machinery may still be in as good condition as it ever was.

In any event, depreciation represents a shrinkage or diminution of tangible property value which must be written off to expense as a part of the cost of maintaining the service, and which must be paid for out of the revenues if the capital so invested is to be preserved unimpaired.

There are two ways by which this may be done:

*First*, by the establishment of a fund out of which all renewals and losses from abandonments are made good, the said fund being maintained by uniform periodical contributions from the revenues; or

*Second*, by meeting the actual expense of renewals and abandonments each year out of the revenues of the same or succeeding year.

Either policy preserves intact the invested capital and charges depreciation where it belongs as an item of expense.

The former method is for some reason to be preferred, chiefly because it equalizes this item one year with another, thus permitting a more uniform water rate, and because it is the practice almost always followed, though in an indirect way. For most water works, unless prevented by restrictive legislation, make provision in their revenues each year for the redemption of a portion of their bonded indebtedness, and under all ordinary conditions such provision exceeds in amount and ren-

ders unnecessary the making of any other provision for depreciation.

It scarcely need be pointed out that a policy of making no allowance at all or of making insufficient allowance for depreciation, and then discarding the structures after abandonment in the determination of value for rate-fixing purposes, is nothing else than confiscation, which by a process of gradual absorption tends to ultimately consume all the capital invested in such structures, with the result of having afforded water service to the consumers at just that much less than cost to the company.

The power that fixes the revenue determines the method by which depreciation shall be cared for, if cared for at all. If that power has made possible the provision of no fund for this purpose, but has, on the other hand, established the policy of allowing depreciation only as the renewals are actually made, the policy should be pursued to its logical and right conclusion and no structures when abandoned be disallowed in whole or in part in determining value until its cost shall have been in the same proportion refunded from the revenue.

Structures which have passed out of existence or which no longer serve a useful purpose may not be included, whether the matter of their depreciation has in the past been rightly or wrongly dealt with.

Structures which are still useful should not be depreciated in determining value without provision being made in the revenues for refunding their cost.

When a charge is properly made against the otherwise value of a property because of structural depreciation, the amount of that charge should not be greater than the estimated present value of an interest-bearing sinking fund which, contributed to annually during the average useful existence of the plant, will equal in amount the investment in the various parts at the end of their usefulness.

If it is the duty of a water company to use reasonable diligence to secure for the future as well as for the present an abundant water supply, a proposition seemingly beyond question, and if this can be accomplished most prudently by the acquisition of properties in advance of their actual requirements for the supplying of water, it certainly seems that such property before its development is in the true sense in use, since it has been purchased for and devoted to that purpose in recognition of the company's duty to the public.

If it has been the settled policy to include such properties, then the investor, being relieved from risk and loss of interest in such investments, might in fairness well feel that the public had acquired such rights as would warrant his accepting a lower interest return, or its equivalent, on the value of such property after it finally comes into actual use than otherwise. In other words, actual cost would then have greater weight in determining value for rate-fixing purposes than the cost of an equivalent property.

If, on the other hand, it has been the established policy to exclude all property not actually employed for the supplying of water in determining value for rate-fixing purposes, thus compelling the water company in the discharge of its duty to carry such properties, it may be for years, at its own risk, then surely this original cost has much less weight in determining their value when they do come into actual use, — unless, indeed, cost be made to include also the losses of interest due to their retention, — and the present cost of other equivalent properties becomes of correspondingly greater importance in determining value.

It therefore logically appears that lands and water rights in general, which of necessity are in the main secured and held long periods in advance of their actual use, should, in the determination of their values after they have been brought into use, have considered their cost inclusive of loss of interest, and also the cost of acquiring a substitutional equivalent. The latter should establish the maximum and the former the minimum when below the latter, provided that the total valuation of the entire water-works property does not exceed the value of the service rendered. Should original cost with interest prove greater than a substitutional equivalent, it demonstrates imprudence for which the consumer should not be held responsible.

### The Estimated Cost of the Reduplication of the Existing Structural Works and Its Relation to Cost and Value of the Existing Plant.

Previously herein have been pointed out the grave objections to adopting the theory suggested by this heading as the sole or even paramount consideration in the determination of value of existing structures when they are sought to be valued simply as structures separately and independent of their relation to the system as a whole.

Nevertheless, it is proper to make such inquiry even though the actual cost of the existing structures may be known with certainty, for the answers will usually be serviceable in determining the degree of prudence and economic skill which has been exercised in the construction of the existing works. In other words, the answer to the query goes rather to the question of prudence in the expenditures actually made than to the value of the structural works in question. This is particularly true where the rate-fixing authorities have pursued the policy of not allowing a revenue sufficient for safeguarding the actual investment in structures against subsequent falling prices and corresponding lesser cost of their reduplication at a later date.

Works of the magnitude here considered never are and cannot be constructed as of any particular date or any particular year. In determining, therefore, the probable cost of their reduplication, it is necessary to forecast the prices of materials and labor likely to prevail, at least during such period of time as would be necessary to carry out the assumed program. To make such forecast, one cannot usually do better than to judge the future by the past and assume as a basis the general average of conditions which have prevailed for a period of years.

### The Estimated Cost of the Construction of Substitutional Works and Its Relation to Value of the Existing Plant.

The estimated cost of constructing independent substitutional works has, for reasons already fully set forth, little relation to the actual value of existing structures, save as such studies may throw light upon the question of the wisdom of the adopted plans after which the works have been built.

Unless such estimates can prove the existence of gross and inexcusable error in the adopted plans, they are not entitled to great weight in determining the value of existing structures.

In determining the value, however, of any combination of real estate and water rights which have together been made a source of water supply for which there exists a demand, the estimated cost of creating an equivalent from the next most available source becomes at least one measure within limits of the present value of the properties and rights already acquired and in use.

This proposition rests upon the theory that since such enhancement of value due to general community growth and prosperity, to which a water company so largely contributes,

is, in the case of individuals or private enterprises, always regarded as legitimate gain, there seems absolutely no reason why the properties of a water corporation devoted by process of law to the public use for no more than a fair annual return upon its value should not share in such enhancement.

The writer has pointed out that this is entitled to special weight in determining the value of water-producing properties when companies are compelled to carry them at their own risk and expense until such time as they are actually required for use.

### Appreciation of Real Estate and Water-Producing Properties and Its Relation to Value.

It seems clear that any determination of present value, if cost be used as the starting point, should be influenced by the appreciation, if any, that has taken place in real estate, water rights, and such like properties since their acquisition by the owners of the works.

It not infrequently happens, especially in the semi-arid sections of the country, that water rights and privileges and real estate so situated as to afford unusual natural opportunities for run-off and storage facilities of an exceptional character, though secured at comparatively small expense, through increased demand due to increase in population, become in time of greatly increased value.

Inasmuch as such enhancement of values is always regarded in the case of private enterprise as legitimate gain, and particularly since general prosperity which creates such enhancement is as largely fostered by a system of water works as by any other agency, there seems no valid reason why such increase of values above original cost should not accrue within limits to the advantage of the water company.

The actual determination of the present value of such assets must, of course, take into account the general scheme of which they form integral parts and the final result as a whole to which they contribute.

No piece of property, however difficult it be to find a satisfactory measure of its value, can be counted as worth less than the cost of other as favorably situated tracts.

If this principle is applied to the combination of properties which, because of their having been brought together, have made possible the delivery for possibly all time of a suitable volume of potable water, then logically the amount of increase in value of such property or its present value would be sought in the

cost of developing or otherwise obtaining an equally abundant and equally marketable supply from the next most available source.

This, then, is the justification for using the probable cost of a substitutional equivalent as at least strongly indicative of value.

This method will usually have its chief application and will most affect the final result in the case of those properties used for creating and safeguarding the courses of water supply as distinct from the distributing system, in those regions of the West where the water supply is the great problem.

On the other hand, where the community has at hand inexhaustible sources of supply free to any one at the cost of taking, water rights may have no value, and no increase in their value then becomes ordinarily possible.

### Has the Franchise any Value?

The answer to this question depends upon what is meant by franchise. If a concern is actually earning revenue in excess of an amount sufficient to meet all costs of production, including a proper return upon the value of the property employed, it has become a very common practice to credit such surplus earnings to franchise. It cannot be denied that under such conditions, by whatever name it may be called, this ability to earn a large surplus, when it may be exercised, constitutes an important element of value.

It appears, however, that the creation of any earning power directly attributable to franchise under this definition, and the consequent creation for it of real value where it has cost nothing, presupposes the entire absence of regulation of rates on the part of government for the purpose of securing water service at no greater cost to the consumers than is consistent with fairness to the water company. In other words, franchise, if it has cost nothing, is not necessarily an element of value upon which any revenue need in fairness be allowed by rate-fixing authorities. Indeed, the very purpose of the law apparently is to prevent such excess earnings as are here assumed to give value to the franchise.

If there are no legal restrictions, and a water company is allowed to collect such rates as seem to it alone expedient, it may easily be imagined that its earnings might in many cases be greatly in excess of what would net it a very reasonable or

even liberal return upon the otherwise value of its property, no matter by what rational method such value were determined.

Again, when water companies have by wise foresight and prudent expenditures acquired properties, such, for instance, as lands and water rights, which by reason of their special adaptation to their purpose cannot be dispensed with without securing other properties productive of equivalent results at a cost materially in excess of the investments actually made, such enhancements of value have sometimes been credited to franchise.

This element of value has already been pointed out to be a very real asset; but it stands in a class by itself. To term it franchise value seems a misnomer since it represents real value wholly independent of the franchise.

Again, the fact that a property possessed of and actually doing a large business capable of affording a sufficient revenue is worth more than a similar property without such business has sometimes been termed franchise value.

This, too, while doubtless a real asset, is better classed as "established business," and will later be again referred to.

The writer is, therefore, of the opinion that the first beforementioned view of what constitutes franchise value is the correct one; that every other element of real value is more properly classified elsewhere, and that under wisely drawn legal provision for the regulation of rates, no value need attach to franchise either for purposes of taxation or revenue.

## Does any Special Value Attach to the Fact that a Company has an Established Business?

Mention has already been made of this element of value. It has been pointed out that a system of works already possessed of sufficient business to make the property a profitable investment is worth more than a similar property without a revenue.

That an established business constitutes a very real asset would seem to be beyond dispute, but the money measure of its value is so difficult of determination that it has at times compelled resort to mere arbitrary opinion. Such a procedure is always to be avoided if a logical standard can be found.

It does not appear that such a standard is wanting where proper accounting has been employed, and its reasonableness lies in the fact that it is rooted in the necessities of water-works construction and growth as demonstrated by general experience.

This measure is found in the actual cost of establishing the business as ascertained by the losses during the early history

of the plant arising from the want of a sufficient revenue to pay at least current rates of interest on the necessary investments. Reference has already been made briefly to this subject, but it is worthy a little further amplification here, even at the risk of some repetition.

The building of water works suited to prevailing needs, with liberal allowance for future increase, is a work of necessity for any modern city, a work which, especially in the regions of sparse rainfall, must, after the first nucleus is formed, precede rather than follow growth in population.

A suitable water service must be obtained regardless of the magnitude of the necessary cost.

Because of these facts it almost invariably happens where local conditions render necessary heavy initial capital outlays, that to some extent the future must be discounted in the early financing of the enterprise. In other words, the limited number of rate payers makes it impossible for the enterprise to pay adequate returns on the investment until the population and business industry, increasing under the stimulus of an abundant water supply and other causes, make possible an adequate revenue.

What is to be the return for this unavoidable additional source of expenditure in the establishing of a sufficient business? Its result is the creation of this asset of "established business," and the attendant expense is an actual measure of what it has cost to create it by the only means by which such an element of water-works value can be created. Cost is, therefore, a rational measure of the value of this element, "established business."

## The Value of the Service Rendered to the Public and the Limitations It Imposes upon Value.

The value of an established water-works property, no matter how great may have been its cost, nor how great a sum would be required to secure a substitutional equivalent, cannot in the final analysis be more for rate-fixing purposes than the capitalization of its greatest possible net earnings without restriction as to charges. In other words, the worth of the service to the consumers will always fix a maximum beyond which no theory of value, however plausible it may appear, can be followed.

What is the worth of the service to the consumers, and how

may it limit the possible revenue and thus limit the value of the water-works property?

*First.*— The service is not worth more to any consumer than it will cost him individually to secure an equivalent by pumping out of a well or from some other available source, if there be any; for if the rate charged exceeds this amount, many will utilize such source in preference, with corresponding loss of revenue to the water company. The same holds good for all consumers collectively, save that in such capacity they may be expected to regard the public welfare as well as that of the individual.

*Second.*— If there is no other possible substitutional supply, thus placing the water company in the position of having an absolute monopoly, still the value of the service rendered cannot be worth more than the consumer can afford to pay interest upon, without impairing general prosperity and checking municipal growth.

To illustrate the above truths: If a water company were wholly unrestricted by any governmental agency in determining the amount of its charges, it would be folly for it to impose rates so high, no matter how great its necessary investment, as to invite destructive competition; and if no competition were possible, it would be just as foolish for it to injure its present as well as its future business by imposing rates so high as to check general prosperity and retard municipal growth. A wise policy and the one calculated to derive in the long run the greatest possible returns would always seek to keep well within these limits, and keeping within these limits, the property could not for rate fixing have a greater value than the revenue then received could support.

If the investment of the water company should prove in the long run greater than the value thus justified by the permissible rates, the loss is chargeable to bad judgment on the part of the investors and they should not be heard to complain.

When one attempts an inquiry as to the value of the service rendered in the specific case of any city, he finds himself, however, without any standards of exact comparison. Water rates charged in different places are indicative of general practice, but each is determined by widely varying local conditions, and none may answer the question directly as to what is the maximum revenue that those local conditions would if necessary warrant. If, however, the rates in question are ascertained by comparison to be materially less than have been successfully imposed with-

out evil results in other cities of comparable wealth and general prosperity, it may be inferred that the application of similar rates would in the case in hand be a safe procedure.

Again, if property improved and unimproved is enhancing rapidly in value, it is evident that the imposing, if need be, upon it of an increased cost of water service would accomplish no worse result than to divide the so-called "unearned increment" due to general increase in population in some proportion between water works and real property.

This phase of the subject, then, deals with the total gross revenues which the company should be allowed to collect, wholly regardless of the magnitude of its actual investment. Its application, therefore, requires the study of general taxation as well as that imposed upon the company, the amount of revenue paid the company in compensation for public service, the cost to the company of operating and maintaining its works, the provision, if any, which should be made annually for liquidating investments in perishable structures or others which ultimately require abandonment, and the rate of interest which the property is entitled to earn over and above all expenses.

While only general conclusions can be drawn from so complex a study, they can, with the exercise of care, be made sufficient to establish the limitations sought with a degree of accuracy suited to the demands of substantial justice.

## Final Summarizing of Conclusions and Determination of Present Value.

Having considered the various hereinbefore enumerated factors likely to influence the value of any property under consideration, and having summarized the results, it will remain to determine the varying degrees of importance and weight to attach to each, and to decide in view of all the attendant circumstances what the amount is upon which the water company is entitled to receive a suitable return.

As has been stated at the beginning of this paper, this final solution can never be reduced to a mathematical formula applicable to all cases. The before-suggested inquiry will have established approximate limitations both as to maximum and minimum, but there will even then usually be found remaining quite a wide intervening field for the exercise of individual discretion.

That the final result will so largely depend upon the personal equation does not of necessity detract from its worth. It

only shows the greatness of the problem which requires for its solution the exercise of faculties higher than the application of mere formulæ and mere routine, faculties which are rooted in laborious thought, in ripe experience, in moral worth.

Justice in dealing with such highly abstract questions calls only for the best that can be had, and nothing less; and the best will always be found sufficient for its ends, for this it is which determines our highest natural sense of justice itself, upon which all law must finally rest.

## A METHOD OF FILING NOTES, SKETCHES AND CLIPPINGS.

By James C. Bennett, Member of the Technical Society of the Pacific Coast.

[Read before the Autumnal Meeting of the Society, December 15, 1905.]

So many descriptions have from time to time been presented of ways and means for filing notes and memoranda, that one almost feels it advisable to introduce such a topic with an apology. In support of this further contribution to the subject, however, it may be said that the writer has investigated most of those methods that have appeared for several years past, and has tried a number of them himself.

In selecting a method of preserving data, there are three principal factors that should govern the selection, their relative importance being in the order named. First, usefulness; this refers to the ease with which reference may be made to the files in the future. Second, convenience in filing the data. Third, expense.

The method that has been finally adopted by the writer as best suited to his requirements consists of one or more loose-leaf books with leaves of the standard 8½ in. by 11 in. bond letter paper, and suitable covers, together with a card index. As the notes are filed they are divided roughly into the various classifications, such as Electric Power, Construction, Materials, etc., according to the individual needs of the engineer. These subdivisions are then provided with a designating letter or symbol, and the leaves numbered consecutively as used, from 1 up to 100, more or less according to the amount of matter to be filed, and according to the thickness of the book that is desired. As the notes are obtained, they are either pasted on to the leaves or copied directly on to them, as the case may be, and the article is then indexed in the card catalogue under the one or more headings for which one is likely to look in the future. There is no attempt made at subdividing the cards, as this only leads to confusion. The most satisfactory way is to place the cards alphabetically only, using the regular guides that usually accompany such sets. The 3-in. by 5-in. card has proved to be the most suitable size.

By way of illustration of the working of the plan, let us wish to look up the cost of the installation of a certain blower and

engine that were placed some time since. We may find the item under " Blower," " Engine," or the name of the firm for whom the work was done. On each of these cards we may find several other items, but there will be no difficulty in identifying the one desired, as there is sufficient description to clearly indicate it. At the right of the line we find the index, " 32–C," and, taking the book which has a large letter " C " on its back, we turn to page 32, where we find the information sought, it may be as a summary or as a description with sketches accompanying it. The record may take up four or five pages, each of which is marked " 32–C–a," " 32–C–b," and so on; thus in case any of the leaves should be misplaced it is not difficult to identify them and restore them to their proper places. This also admits of future additions to the original, should later developments render it desirable, by using the next sub-index on the newly added sheet, without in any way disarranging the leaves already in place.

Some question may arise in the minds of some as to the reason for dividing the data up into the several headings, and, in answer to this possible question, it is done only to facilitate the handling, as it saves looking over so many pages; in short, it is in the nature of dividing a lengthy subject into volumes. Of course there are many notes that come to one's notice which it is difficult to classify clearly. In such cases, there is no harm done, or future inconvenience occasioned, if they are not strictly and correctly placed, as the different volumes are, as has just been stated, for convenience in handling and not necessarily for strict subdivision. Hence, in the illustration just cited, it would have been fully as easy to find the memoranda on blower installation had it been placed in the volume on steam power, and accordingly indexed.

The standard letter size was adopted because of its convenient size for handling and because it affords sufficient space for quite copious notes. Further, by using such paper and size, charts and tables may be made directly on the leaves, and, if it is desired, blue prints may be taken at any future time. In the writer's files there are also several such tables on tracing cloth, cut to proper size, and some that are folded once, which, in those particular instances, could be done without obliterating any of the important matter. Again, it sometimes happens that there are several pages of printed matter devoted entirely to a particular subject which are smaller than the standard size, or can be so trimmed. In such cases it has seemed best to place

the entire article on one sheet, thus forming a small book or pamphlet within the main volume and having but the one principal number.

Probably the most important point of this method of filing is the selection of a suitable cover and binder for the books. The writer has tried some six or eight different covers for this purpose, and as a result of the experiments is convinced that the proper selection of a cover is the one thing that really renders the notes truly useful or merely ornamental. The two principal requisites of the cover are, the ability to remove a leaf occasionally without disturbing the remainder of the book, and the ability to insert additional matter without disarranging the pages which follow. After having tried a number of the binders, one, known as the Irving Pitt Price List Cover, was found to approach most nearly the fulfillment of the important conditions that have been cited. This cover is provided with snap rings which are divided midway between the covers, so that it is an easy and simple matter to remove or insert a leaf at almost any part of the book without disarranging any of the preceding or following pages.

The method which has just been described cannot claim for itself the lowest first cost, but, as indicated at the beginning of this description, the cost is, in the writer's mind, the third of the most important requisites of an efficient means of filing data. Thus the method under consideration conforms fairly closely with the conditions imposed, namely, usefulness, convenience in filing and expense.

## PROBLEMS THAT CONFRONT ENGINEERING AND KINDRED INDUSTRIES ON THE PACIFIC COAST.

By George W. Dickie, President of the Technical Society of the Pacific Coast.

[Read before the Pacific Coast Engineering Congress (Lewis and Clark Exposition), at Portland, Ore., June 29, 1905.

The physical problems that have to be encountered by the engineer in his efforts to bring the vast territory known as the Pacific Coast into the best productive condition, and to render it a desirable and comfortable place to live in, are peculiar to this side of the continent. The conformation of the face of the country, the character of the rock strata, the extreme condition of wetness in one locality and a similar condition of dryness in another locality, with a sparse population that limits the possible expenditure, are problems that our engineers have struggled with during the last fifty years, and they will be with us for fifty years to come. These problems can be safely left with the engineers now battling with them and to those who will follow them in the fields now occupied and in the new fields of enterprise that time and conditions are continually opening up. The problems I wish to bring before you at this time are not those of a physical character but are those that may be said to come within the department of economics. By engineering and kindred industries I mean all establishments whose business involves constructive engineering in all its branches; this includes all manufactures in metals although not strictly engineering. In all this class of industrial products labor forms a large percentage of the total cost of production; and, in order to reduce costs to the lowest possible point, manufacturing establishments must confine themselves to a certain line of output, perfect that line both in design and in method of production, having special tools for each stage in the process of manufacture. To make this possible a large market is necessary for each kind of product. These conditions, so necessary to successful production of the numerous and varied mechanical devices required to carry on our modern civilization, are not yet present on the Pacific coast; gradually they will come with population, but we are yet very far from the conditions that will make industrial engineering an assured success amongst us. In many respects the general

engineering establishment on the Pacific coast was better off, as regards the certainty of business, thirty years ago than it is to-day. At that time the agent or representative of the manufacturer of machinery in the more densely populated parts of the country had not yet established himself on the Pacific coast, and whatever machinery was required here for mines, saw mills, flour mills, steamboats, street railroads, etc., was built to order by some local engineering establishment on the best terms his customer could make with him, and usually for some special type of machinery suited to the requirements of the case. Thus in some cases the best type of machinery for certain purposes originated on this coast, and some notable examples of bold engineering were carried out successfully that engineers in more settled communities would not have dared to undertake. Yet this very originality of engineering conception rendered the establishments that carried out such projects quite unfit to undertake the manufacture of machinery on economical lines. As soon, however, as the amount of machinery required on the Pacific coast was sufficient in volume to attract the notice of manufacturers of special types of mechanism for various purposes, representative agencies were established in the centers nearest to where the bulk of such machinery was required, and the representative, representing, as he usually does, many manufacturing establishments and being well furnished with plans, illustrations, and specifications of the machinery he can furnish, is in a much better position to secure the general run of work of this character than the local establishments that have nothing that they manufacture to meet any general demand, but build some special machines to meet as far as they can the special needs of their customers; and herein lie the difference and the problem that the local establishment must solve or fail to reach permanent success. The agent representing several large manufacturing establishments whose markets cover the needs of the whole country and who make some special standard type of machinery well designed to meet the general requirements, has only to persuade his prospective customer that generally the machine he offers is the best adapted to the purpose in view and that it will be for his interest to modify any special condition in his case in order to use the standard type; and this reasoning promising, as it usually does, a saving in outlay, has a pretty good chance to succeed. The local engineering establishment has but one chance, and that is to persuade its prospective customer that the special conditions of his case cannot be

ignored or changed without risking the success of his enterprise, that the machine that will entirely meet all his requirements successfully cannot be secured from the stock of any manufacturing establishment, but must be specially designed to meet his special conditions, and that though it costs considerably more, yet in the long run it will prove the best for him. Though the reasoning of the local engineer is not always true, for he tries to magnify the one condition as much as possible, it is still a fact that the prospective customer seldom gives proper value to the condition demanding special treatment, but takes the easiest course, the one requiring no study of conditions, examination into special plans, etc., and is inclined to accept the standard machine that can be delivered quickly and which he can actually see before he buys. Thus the local engineer is outdone by the local representative of a distant manufacturer, and the business that should support local establishments, increasing our wealth and population, goes away to enrich other communities. Here is a problem for both the engineer and the capitalist. The engineering business on the Pacific coast does not suffer for lack of ability on the part of the managing engineers, but rather because of too much brain.

If a Pacific coast engineering establishment has to compete with an eastern establishment on an engineering proposition instead of a manufacturing proposition, even though freight and wages be heavily against the Pacific coast engineer, his ability to handle new problems as they come to him will enable him to practically hold his own in the fight. This has been very forcibly illustrated in the building of naval vessels on the Pacific coast. One concern has kept on building war ships at San Francisco, and has evidently done as good work and with as good result in the way of profit as any of the eastern establishments with which it has been in competition. This goes far to prove that for work that is not simply repetition the Pacific coast engineer can and does hold his own against work of a similar character produced on the Atlantic coast.

How, then, is he going to adapt himself and his establishment so as to keep that establishment going with full power, with a large part of his work of the character that forms the standard work turned out by the eastern manufacturing establishments?

He cannot hope to extend his market beyond the limits of the Pacific coast under the conditions in force here, and on that account cannot manufacture in the same sense that his eastern competitor does. He has some advantages, however, that count

in his favor. The cost of maintaining agencies, and commissions on selling the standard manufactured machinery, is probably not less than 25 per cent. of the total cost, and this should help the local engineering establishment; but as things are usually managed this advantage is not nearly enough for the local concern and may be entirely eliminated by the manufacturer whose market extending over the whole country gives him the chance to sell cheap at any place where the local establishment tries to sell the same class of machinery.

The prospect, in California especially, has brightened somewhat of late, owing to the discovery of great subterranean stores of liquid fuel, which generally means a saving of 50 per cent. in the fuel bills of an engineering establishment; besides, it makes enterprises such as electric generation for lighting and power purposes possible that would not otherwise have been attempted, thus creating new fields for the engineering talent and the constructive ability of the country to work in. A good deal of this new field, that of the cheap generation of electricity either through the burning of liquid fuel that comes from below or the falling of a purer liquid from the mountains, is, I am sorry to say, not being cultivated by the local engineering works as it might be. I believe there is a splendid opportunity at the present time to establish somewhere on the Pacific coast a great electrical establishment which would turn out complete electrical generating plants operated either by steam engines, water motors, or steam turbines. The field for this class of work on the Pacific coast is a large one now and will grow steadily until it becomes one of our greatest industries. I have had some experience in the building of electrical generating plants on the Pacific coast, the work being done in connection with a much larger output of general engineering work; and under these conditions I found it quite possible to build at a cost never greater than the selling price of similar work manufactured in eastern establishments as standard work. This leads me to believe that an establishment devoting its undivided attention to supplying the needs of the Pacific coast in electrical engineering could build up a splendid and profitable business, combining well designed generators and equally well designed engines or water wheels, and taking in also all the engineering accessories that form part of any completed electrical generating plant. The principal factor in such an enterprise would be the cost of labor. As this item will be between 50 per cent. and 60 per cent. of the total cost of production, its regulation will always be of the utmost importance.

The rate of wages by the present system of compensating labor will, I think, be always higher on the Pacific coast than it is elsewhere. Perhaps no other reason can be given for this condition than that it is so and is likely to be so indefinitely; but while the rate of wages is higher here, I do not think that the amount of wages paid for a given result need or should be higher here than it is elsewhere. I have for some years back been advocating a system of compensation for the labor in such establishments, whereby the men as a whole who are to do the work should contract with the owners of the establishment in which they work for the whole labor involved in producing a certain industrial result; this would enable the workmen to decide whether they could afford to do the labor part involved in producing certain kinds of machinery for such an amount as would make it possible for the establishment in which they work to undertake the production of such machinery. There are four factors that go to make up all estimates of cost in the class of industrial products we are now considering; these are:

*First.* — The prime cost of all the materials required for the proposed work to be done.

*Second.* — The actual cost of all labor necessary to convert the materials into the finished result ready for delivery to or acceptance by the customer for whom the work is done.

*Third.* — The proportion of the general expense account chargeable on such estimate.

*Fourth.* — Profit.

No work can be properly entered into by any industrial establishment, either as a contract or as something to be manufactured and sold as a finished product, without a careful estimate being made of all the items forming these four factors in the completed cost.

The estimator, if his work is to be a safe guide for the firm or company that he represents, must have correct information as to the amount of and the cost of all materials to be used in carrying out any proposed contract or the manufacture of any product for the market; this item is within the capacity of a competent man to have correct, so there need be no doubt about the first factor in the completed cost. The third item in the cost is the difference between the net and overhead costs, providing for the proper share of the general expense account. There is some difference of opinion amongst those who manage engineering establishments as to what should form general expense. I have always held that all charges of every nature that cannot be

charged directly to the individual job should be charged to this account. This would include the cost of general management, all foremen in charge of more than one job, all handling of material until it is charged to some particular work, all fuel and water bills, the whole office force except draftsmen that are charged directly to the job they are working on, taxes, traveling and advertising expenses, repairs and depreciation. If, for instance, an estimate were being made the approximate amount of which was $1 000 000, and the total amount of work done the previous year was $5 000 000, and the general expense account including all items not chargeable direct to a specific job for the year was $500 000, then the item for general expense in an estimate amounting to $1 000 000 would be $100 000. There is no reason why this important factor in the estimate should not be correct, and to keep it as low as possible and still be correct has an important bearing on the success of the business in question; the larger the output in proportion to the general expense the less the prime cost of the article produced.

The second item in the cost, the actual cost of all labor necessary to convert the material into the finished result ready for delivery to or acceptance by the customer, is the uncertain factor that brings the element of speculation into the estimate; and while it forms the largest single item of the estimate, the estimator can only approximate its cost from past experience; what the ultimate cost of the labor will be depends largely upon the relation between his company and the men who are to do the work.

The variations in the cost of labor on the same amount of work done at different times, resulting from different men and different conditions, is often sufficient to wipe out several times over the estimated profit on a contract; and I have often thought that if it were possible to make the labor item in our estimate a sure thing it would bring new life and vigor into engineering industries over the Pacific coast. There is a certain amount available for the compensation of labor in the estimated cost of the product in any industry, and that amount cannot be exceeded under a given condition of market. If the fourth item, that of profit, were 10 per cent., an addition of 20 per cent. to the labor item would completely wipe out profit. This variation of 20 per cent. in the cost of the labor item is not an unusual occurrence under the present system of compensation for labor.

In estimates involving many trades and large numbers of men, even under ordinary peaceful conditions, large allowances

must be made for incompetent men and unwilling hands that wait for time to move on to pay day and have no interest in what has been produced for the pay they receive. My experience has led me to the conclusion that a desire to do the very best they could by all hands every day would, in engineering establishments that pay their men for the time they are at work, practically double the labor result. How can this desire to work be excited in the workman? I have carefully studied several methods in use to encourage this desire to work, at industrial establishments both in this country and in Europe, having for their object the compensation of the workmen in accordance with the work produced without the objectionable feature of piece work. Piece work and most of the premium plans deal with the product of the individual man, and, besides raising comparisons between the men themselves which are odious here as elsewhere, can only be applied to such parts of the work as can be readily separated from the general work being done, and in large establishments cover only a small portion of the work. My experience, combined with a careful study of this subject, has forced me to the conclusion that the only way to get the best result out of all the men employed in a large industrial establishment is to combine them all by mutual interest in bringing about the best possible industrial result, and into that combination the employer must also bring his interests. The working man must first be made to understand that the establishment in which he works must be run at a profit or it will soon cease to run at all. The possible profit is a difficult thing to get the men to understand; many workmen, gathering their information from the wild statements made by labor leaders and a certain class of newspapers, have very exaggerated notions of the profits made in engineering industries. I had occasion some time ago to speak to a number of workmen bent on forcing very hard conditions on their employers, and the question of profits was brought up during the discussion, showing that their ideas of what it was possible for their employer to do, and yet have something left, were quite remarkable; nor could any impression be made upon them by the statement that in eighteen years their employers had paid out in wages \$28 000 000 and that during the same time the stockholders had been paid \$1 300 000 in profits, or less than 5 per cent. of the wages paid. This would have given each workman one and one-half cents more wages per hour and the stockholders nothing, yet these same men, if they had all worked their best, might have readily doubled the result and thereby

increased materially both pay and profit. In the attempt to solve the problems involved in labor costs on the Pacific coast the main thing that both the employer and the employed must accept as the foundation for any scheme that is to permanently bring about proper and natural relations between them and give hope in regard to our industries, is justice; without that nothing can be done. The one side must have perfect confidence in the justice of the other. If this attitude can be assumed and maintained all other difficulties can be overcome. Most of my thinking combined with some action on this problem has been in connection with engineering industries, and I would like to state to you, as far as I can in words, how I would propose to solve the problems in the cost of labor. I have stated that in all estimates labor is or should be treated as an independent factor, and it is the most difficult of all the factors entering into an estimate to determine. What it should be to meet the market value of the work produced is within the power of the experienced estimator to decide; but what it will be depends entirely on how the men that are to do the work feel about it. I have found out a curious fact about this question of labor values; that all the intelligent workmen whom I consult with about it set a much lower value on the labor required to produce a given result than my experience tells me is necessary. They instinctively think of what a man could do if he tried, while I have been forced to figure on what he generally does; and thus, what under ordinary circumstances an unwilling man can be persuaded to do has become the measure of the value of labor in the estimates that are regularly made in engineering works where the men are paid for time instead of for work. In engineering estimates the labor item will be from 40 per cent. to 60 per cent. of the total amount. Very few workmen believe this; in fact I have generally found them under the impression that the profit was from 40 per cent. to 60 per cent. An average proportion for general machinery estimates would be:

| | | |
|---|---|---|
| Labor | 40 | per cent. |
| Material | 40 | ,, |
| General expenses | 12 | ,, |
| Possible profit | 8 | ,, |

With this proportion, which may be taken as roughly correct, an increase of 20 per cent. in the cost of labor would completely wipe out the item of profit.

Suppose, then, that our engineering establishment agreed with all the men employed in the works that the amount set

aside for labor in any estimate should be accepted by the men employed as a whole as the compensation they should receive for performing all the labor required to complete the work represented by that estimate. All the men employed in that case would have to be represented by a committee of themselves, say one from each department of the works, who would go over the estimate of labor with the representative of the works who made the estimate, and accept if satisfactory on behalf of the men they represent. This might be done before the tendering for the work, so that the workmen themselves would be tendering for the labor part of the proposed contract. The question might be raised here as to the ability of those representing the men to determine as to the correctness of any estimate for labor, whether the employer has all the skill and experience necessary to make his estimate of labor, while the representatives of the men do not, as a rule, possess this skill, and whether the men would therefore be at the mercy of the employer. There need be no fear of this difficulty, as the men are not likely to appoint representatives who are not thoroughly competent to watch their interests; in fact, as already stated, the men are apt to place a lower estimate on the value of labor than the employer. The employer, as at present, would ultimately have to stand the chance of possible loss, but that chance would be very much less than it is at present, as the possible gain by the workmen would be an incentive to every one to do his best.

Under such an arrangement I would propose to engage all the men just as they are employed under the present system, the foreman rating every man at what he considered him worth per day; or, to meet the altruistic ideas now prevailing among the trades union men, a uniform rate could be decided upon for all the tradesmen; rates also would be fixed for apprentices learning trades, and rates for laborers. Each man's or boy's rating would be posted up in the department in which he worked, and his fellow workmen through their committee should have the right to have this rate reduced if they found that the work he turned out was not equal to his rating. All wages would be paid as at present according to the rating. The full amount for which the men had contracted to do the whole labor on any job would be placed to the credit of labor on that job, and the wages paid out on that job would be charged against that account. As each job or contract was finished, the unexpended amount on that particular job or contract, if any, would then be credited to the labor surplus account. If on any job or contract the wages paid

should be more than the amount accepted for labor, the difference would be charged to the labor surplus account. At the end of each year the amount that had accumulated in the labor surplus account would be available as a dividend on labor, and whatever percentage it formed of the total amount paid for labor during the year would be the percentage each man would receive on the amount he had earned during the year.

This enables each workman to participate in the profit of the labor part on all work done in the establishment, whether he was a long time or a short time employed during the year, and without any reference to the particular job he may have worked on; so that no matter what he may be doing or in what capacity he works, how he does that work will either swell or diminish the general dividend, and every man will see to it that his fellow workman does not reduce his dividend if any instruction on his part will prevent it.

I believe the time has come when the item of labor must be dealt with by methods different from the present ones. It cannot be considered as an article that can be bought by any time-measuring arrangement. The time has come when it can be contracted with; its hopes must be taken into account; it must have something to strive for or it will not strive at all. I believe that the difference in result between the work of earnest workmen who try to do the best they can and whose recompense is measured by what they accomplish, and the indifferent labor that is forced out of men by constant watching and urging during a certain number of hours, is so great that it would practically compensate for the difference between the cost of production in the manufacturing establishments of the Atlantic coast and the cost of production under existing conditions on the Pacific coast. I fully understand that such a system of compensation to workmen as I have outlined presents difficulties of a special character in every kind of business. I have studied it very carefully in its application to an engineering business and have reached the conclusion that some such plan as I propose will be ultimately accepted by both employer and employed as the only solution of the labor problem as it affects industrial engineering. Courage and honesty combined with the right kind of skill on the part of those managing such concerns would, if patiently applied, result in such benefits to workmen and to those with whom they work as would save many an industry on this coast which under the present unjust methods of dealing with labor problems has nothing before it but impending ruin. I have dwelt thus long on

the labor problem as it affects the possibility of constructing here on this coast the great bulk of the machinery required in the development of our resources, because it is, after all, the great and only hard problem that confronts us. Give labor the place that its importance demands in the councils of men. It is 40 per cent. of the problem of operating successfully any engineering establishment and should have its say in regard to that 40 per cent. if admitted to council. Labor unions would soon lose themselves in labor associations represented by directors of their own choosing, who would be a 40 per cent. factor in every estimate that was made and who would be able to give and take with the other 60 per cent. in order to meet the conditions of market values. If the manager of an engineering establishment could meet the representatives of the workmen when making up his estimate for work to be done, and settle with them the cost of the labor part of the estimate, just as he meets the steel manufacturer and settles with him the cost of the part that he is to furnish, then mutual concessions that might be necessary in order to prevent the work from going elsewhere could be made without the feeling that either party was trying to get an advantage over the other.

Our universities are training large numbers of young men in the various branches of engineering, and out of our common schools are flocking thousands of youths eager to find places in the mechanical crafts, probably one hundred for each one that can get a chance, because one commission agent can sell as much finished work as will keep 500 hands at work in some far-off establishment, while a corresponding number of hands are idle here. The Pacific coast will make slow progress in the mechanical arts until conditions are such as will enable us to do much more of our own work than we are now doing. What is usually termed " business management " is also a factor in the success of any engineering industrial enterprise. The ability to make something well and economically must be combined with the ability to sell it to the best advantage and in the nearest market; these two qualities are not often found in the same individual in their highest development. Still, a good engineer should also be a good business man. Both of these faculties need common sense and the habit of thinking clearly, backed by an educated judgment. Of these two requisites, however, the engineering business is most dependent upon the ability to make the proper thing for the work in hand at a price that will enable it to enter the market and compete successfully. In other indus-

tries the business faculty is the dominating factor in success. In some industries the cost of manufacture is but a small percentage of the cost of the finished product; in such cases business management in buying the raw material at the one end and in selling the finished product at the other end of the completed transaction is of vital importance. Take the sugar refining industry, that may be said to have succeeded on the Pacific coast. The cost of refining sugar in a first-class modern refinery is less than one eighth of a cent per pound, while the fluctuations in the price of raw sugar and of the refined product may be many times the total cost of refining in the course of a year or two. In such cases success depends chiefly on the business management; but in the engineering industries the purchased raw material does not cost more than about 40 per cent. of the value of the finished product, hence the importance of shop economy where the other 60 per cent. is expended. The problem for the engineer to solve is, How can I, on the Pacific coast, with all the elements that go to make up that 60 per cent. costing more than anywhere else, bring about a final result such as will enable me to sell my product at a price that will not be greater than the product of another establishment so situated that the elements that go to make their 60 per cent. cost less than they do here? It is just such industries, the problems connected with which are so hard to settle, that are of most importance in the development and building up of the Pacific coast. The volume of business done is not always a true measure of the prosperity of a state. The kind of business done is often of more importance than the amount. An agent selling $100 000 worth of machinery on the Pacific coast and receiving 10 per cent. commission can only distribute $10,000 in the community out of the $100 000 spent, while if the same machinery had been made here, $60 000 would have been distributed in the community out of the $100 000 spent. Compare the business of sugar refining, already mentioned as having succeeded on the Pacific coast, with an engineering business which I will suppose to be also successful:

| | |
|---|---|
| The refiner buys raw sugar to the extent of .............. | $5 000 000 |
| Cost of refining.................................. | 187 500 |
| Total cost of product ready for the market ........ | $5 187 500 |
| The refiner sells this product at ........................ | 6 687 500 |
| Refiner's profit ................................ | $1 500 000 |

The refiner may take his profit anywhere and spend it, or he may reinvest it in the community and thus build up the state,

but the immediate distribution that takes place is only the \$187 500, or the employment of about 235 men.

| | |
|---|---|
| The engineer buys raw material to the extent of | \$5 000 000 |
| Expends in converting raw material into machinery | 7 500 000 |
| Total cost of product ready for the market | \$12 500 000 |
| The engineer sells this product at | 13 500 000 |
| Engineer's profit | \$1 000 000 |

The engineer may, like the refiner, take his profit anywhere and spend it, or he may invest it in the community and thus help to build up the state, but the immediate distribution that takes place is \$7 500 000, or the employment of 9 375 men. This illustrates the difference between one kind of business and another as to their effect in building up a state; the unfortunate thing is that the business that produces the greatest difference in cost between the raw material and the finished product should be the most difficult to establish as permanent enterprise on the Pacific coast. If our labor costs could by any such plan as I have outlined be made to approximate what they are on the Atlantic coast, I believe that we could build here all the machinery, ships and other engineering products that the development of the Pacific coast requires. We should thus soon acquire a population that would give impetus to every enterprise and start this whole great territory on the high road to such a development as is not now dreamed of by the most advanced optimist amongst us.

## ANNUAL ADDRESS.

By George W. Dickie, President of the Technical Society of the Pacific Coast.

[Delivered before the Technical Society of the Pacific Coast at the Autumnal Banquet, December 16, 1905.]

Having served you two terms of 2 years each as president, I cannot hope to be called again to that responsibility, but whatever my place in the Technical Society of the Pacific Coast may be, my interest in its welfare will never be other than it has been. It has been my honor to be connected with this society since its beginning and among the many societies with which I am connected, the Technical has and will, I trust, always have the first place in my heart.

In my inaugural address delivered before the society at its spring meeting, May 26, 1904, I gave you my impressions in a general way on the present and future of engineering on the Pacific coast. These impressions were expressed perhaps more fully in my address before the society at its spring meeting of this year, held in Portland, Ore. As I can add little or nothing to what I have already expressed as to the future prospects of engineering on this coast, perhaps it would not be out of place, in this retiring address, to look backward and reflect somewhat on the way by which we have come to this present. One does not need to have had a very brilliant career in engineering to find sufficient material, out of 36 years of active working experience, for an address that will, I think, interest the members of this society.

Beginning with the year 1869, when I came to San Francisco, a young man full of many ambitions that have never been realized, I was attracted here not from any knowledge of the place or its people, as I knew no one except the members of my immediate family with whom I came, but from a simple study of the map, acquiring a firm conviction that a city holding the position of San Francisco, with an open door to the Pacific Ocean and forming a part of a great progressive nation like the United States, could not fail to offer opportunities to a young man who had some confidence in himself and was not afraid of any amount of hard work that might lie between him and his ambition. The ambition was to be permitted to take an impor-

tant part in building the ships that would be required in developing the ocean commerce of such a city, for shipbuilding and marine engineering were what I thought I knew something about. In 1870 there was little or nothing doing in my specialty in San Francisco and I had been here some months without finding any opportunity to show what a clever chap I was. Reading the newspaper one day my eye caught an advertisement wanting a competent man to do the planning and erecting of a gas works plant; apply to the Risdon Iron Works. I looked hard at this advertisement; a competent man was wanted and I considered myself competent, but this man was wanted to plan and erect gas works and I knew little or nothing about gas works. Nature had endowed me with the faculty of using a little gas to help myself when such help was needed, but in this case I had not enough knowledge to warrant it expanding to the required bulk; this, however, was the only thing I had seen for any man to plan in the months I had been here. I wrote to the Risdon Iron Works saying that I would like to undertake the work for which they wanted a competent man, and asking for an appointment to see them about it. Having posted this letter, I went at once to the Mechanics' Library and sought out eagerly all they had on the subject of gas and spent the next 2 days steadily imbibing all the obtainable knowledge relative to the erection of gas works. The next day I was asked to call at the Risdon Iron Works; there I met Joseph Moore and started a friendship that lasted about 15 years; it should have lasted longer, but Mr. Moore thought that I had in some way done him an injury, and for the last 18 years of his life we were estranged. I desire to take this opportunity of saying that I do not think that Joseph Moore got the recognition on the Pacific coast that he deserved. He was a master mechanic of no mean ability, and his capacity for work in his best days was something enormous. He was the father of the riveted pipe as a great water conduit; he had also much to do with the early development of the special types of mining and ore-treating machinery that originated in California.

Mr. J. B. Haggin, then a trustee of the Risdon Iron Works, was to build an opposition gas works for San Francisco. The new works were to be located at the Potrero and the owners had intrusted the iron work to the Risdon Iron Works; hence the advertisement. Fresh from my study of the literature on gas works, I was able to impress Mr. Moore with my ability to take charge of anything that he had in that line and was engaged

for the work on which I was to begin next day. Mr. Moore had Mr. Haggin's engineer at the works to meet me, and I was introduced as a gas expert; this was fortunate indeed, as this engineer was quite innocent of any experience in the building of gas works and had not read the subject as I had; thus my reputation as an expert was safe. Plans of a newly-finished gas plant, in Philadelphia, were furnished as a guide and I found no difficulty in making what was wanted here. The works were built and put into operation without any trouble, while I was considered a pretty fair gas engineer.

About this time, when I was at the height of my fame as a gas engineer, the Pacific Mail Steamship Company concluded to fit one of their side-wheel steamers with a surface condenser. One day I heard their superintending engineer talking the matter over with Mr. Moore and wondering where they might get hold of some one who had had some experience in building surface condensers to take charge of this work; so as soon as Mr. Moore was alone I suggested to him that he put this matter in my hands and I would see it properly carried out.

"No," said he, "that would never do; you are a gas engineer, and this needs a marine engineer who knows all about surface condensers." As my ambition could not be reached by the way of gas engineering I had to confess the trick that I had played upon him in the matter of gas, and produced my letters of recommendation from engineers and shipbuilders in Scotland as evidence of my ability as a marine engineer, and finally succeeded in getting a start on the road that I have trudged along ever since. The surface condensers for the Pacific Mail Steamship Company were built and installed, the result proving very satisfactory. There were no compound engines in any of the boats on this coast at that time; in fact, I had built several of them here before they were introduced on the Atlantic. John Roach had the engines for the steamship *Granada* built in Glasgow and sent out as a pattern some years after the date I am now speaking of. About this time we secured the contract for the machinery of a coasting vessel named the *East Port*, to run between San Francisco and Coos Bay. The engine was of the single-cylinder type, 34 in. diameter by 34 in. stroke, surface condensing. I tried to have this changed to a compound engine, but the owners would not hear of it. The steam pressure was to be 70 lb. per sq. in., and instead of the fire-box type of boiler then prevalent I managed to get the consent of the owners to substitute a cylindrical Scotch 3-furnace boiler, 13 ft. diame-

ter and 11 ft. long. The inspection laws at that time limited the thickness of plate on which the fire impinged to 0.26 in., and the boiler inspector here at the time ruled that this requirement applied to the furnaces of my boiler and insisted that the furnace plates should not be over 0.26 in. in thickness; this forced me to put forged rings on the outside of the furnaces, about 10 in. apart, and with a water space between the furnace plates and the rings, the plate being secured to the rings by stay bolts about 10 in. apart. This boiler, while being built, was the object of much adverse criticism by boiler experts and its failure was confidently predicted. When it was standing on the dock waiting to be placed on board, the United States boiler inspector looked at it carefully for a while and then said to me,

"Mr. Dickie, what size of a steam whistle do you propose to put on this boat?"

"The usual 6-in. whistle, Mr. B.," I replied.

"Now don't fit anything as big as that, my boy; that boiler will never make steam for a 6-in. whistle."

The same day the president of the Risdon Iron Works made a last effort to shake my confidence by stating that many people had advised him not to permit it to go in the boat, that it would be better to make another boiler as quickly as possible and not add to the present loss by going any further with a boiler condemned by everybody. With Mr. Moore's help, however, I was allowed to go on, and to the astonishment of all the wise ones on the city front the boiler did very well, as I expected, and there was no difficulty in getting the 350 h.p. that the contract required. The revenue cutter *Oliver Wolcott* was also built at this time with a single-cylinder engine. I went so far as to directly urge the Treasury Department to let me change it to a compound, but Mr. Emery, their engineer, would not have it, although in the next cutter built compound engines were fitted.

The Hawaiian government decided at this time to have a steamer to carry the mails between the islands, and Mr. Sam Wilder came up to San Francisco to see about it. I designed him a vessel such as he required and to meet the appropriation for building her, and she was the first steamer built here with compound engines. Before she was completed Mr. Wilder made arrangements with his government whereby he should own and operate the boat, and thus the "Like Like" started what is now a large inter-island navigation company.

From this time on I had the pleasure of building many boats

and engines that have done good service on the Pacific coast. These boats were built of wood, culminating in the steamship *Mexico*, the largest wooden steamship for ocean service that has been built on the Pacific coast. Notable among these vessels was a fleet of steam whalers built between 1879 and 1883. I had the honor of fitting to one of these, the *Balaena*, the first marine triple expansion engine built in the United States.

Now I must take you back to 1874, to the beginning of lively times on the Comstock. Long before the Sutro tunnel reached the group of mines it was expected to drain, and through which the ores were to be transported to the mills on the Carson River, the shafts had been sunk to a depth nearly twice that at which the tunnel was to join them, and great hoisting and pumping works were required to enable the mines to be operated. The mines in operation were divided into two groups, known as the north and south end mines; and they were usually in the control of two groups of capitalists known as the Bank of California crowd, and the Nevada Bank crowd, also known as the Bonanza crowd. The Risdon Iron Works was generally favored by the Bank of California crowd, while Prescott Scott & Co. were generally favored by the Bonanza crowd. I, as engineer of the Risdon Iron Works, was pushed into the wild scramble for the rich jobs that characterized this period, my opponent being Mr. Irving M. Scott, of the Union Iron Works. I might say something here in regard to the late I. M. Scott; for 10 years he and I kept up a brisk rivalry in engineering design to meet the unusual conditions presented by the problems encountered in working the Comstock mines; he was a noble fighter, and one could not help liking him even when it was felt that the victory should have been ours and not his. Mr. Scott was so brilliant in many ways that his ability as an engineer was often lost sight of. Perhaps no one knew him better as an engineer than I did, for we not only worked in competition with each other for 10 years, but we worked together as junior and senior partner for over 20 years, and I am glad to be able to bear testimony to his skill in engineering design and to his masterly powers of organization to bring his design into an accomplished fact. My association with Mr. Scott I consider as one of the pleasantest experiences of my life as an engineer.

The Comstock experience left two distinct results that have borne fruit and exerted a lasting influence on engineering and industries allied thereto on the Pacific coast; one of these results has been productive of much good and the other of much

evil. The engineer who planned and built the huge machines required to meet the new conditions of mining in deep water-bearing strata where chemical conditions heated the water to be handled to near the boiling point, and erected them in places where the heat hardly allowed of life, let alone work, and where a drop of water raised a blister on the skin, had to cultivate self-reliance and had to be full of engineering resources. Many methods were put in operation in this out-of-the-way corner of the world, when there was not time to make records, which have been reinvented since, such as compressing air in two stages and the reheating of air during expansion while doing work. Much original work in hydraulics resulted in attempts to drain the lower levels of the Cholar Norcross and Savage mines through their combination shaft; all this work was designed by me without any precedent to go by, and feeling one's way under the conditions that prevailed in these mines was an education in how to control one's nerves if nothing else. On the 2 400-ft. level running into the old Savage workings we had a stone wall built across the drift, with a pipe and a valve on it to control the flow; when things went wrong and the valve had to be closed the water would rise behind that wall till it stood at 1 700 ft. I often looked at the pressure gage and imagined how it would be if that wall let go. Air chambers had to be charged under a pressure of 2 500 lb. per sq. in. and air compressors designed and built to do it. What we did there gave us courage afterwards to build battleships. This schooling has enabled the Pacific coast engineer to hold his own in all work requiring original design to meet unusual conditions, but at the same time unfitted him for competition in the manufacture of standard work. The big prices paid for work in Bonanza times is still felt, both in the design and in the building of machinery on this coast, and it is to be hoped that it may die with the engineers now nearing the dropping-off side of the stage.

It is much to be regretted that the history of the engineering battles fought on the Comstock cannot now be written with strict justice to all who fought in them. Those, like myself, who were in the thick of the fight could only see and feel their own struggle and narrate what they experienced; but the whole struggle, with the stupendous natural obstacles encountered by the engineers in their attempts to get at the secrets nature guarded so carefully, cannot now, I fear, ever be revealed by any of those who took part in the work. I have often talked with Mr. W. R. Eckhart about it, and I think that he has more

notes of what was done than any one else, but he has not seen his way to use the information he has. Such a history would be a rare possession for the Technical Society of the Pacific Coast, and I have never forgiven myself for not recording all that came within my own observation as it occurred, as memory plays many tricks upon us if we try to drive her back 30 years or so, and I will not risk the danger of her leading me astray.

In 1881 I began to think it necessary for some concern to get ready for steel shipbuilding at San Francisco or vicinity, watching the growth of Pacific Ocean trade and the necessity of keeping a large force of the right kind of men at work to meet the demands that would come suddenly at uncertain intervals for large numbers of men to effect repairs required by accident or otherwise. There was also a growing feeling throughout the country that a modern navy was necessary to enable the United States to take her place among the leading nations of the earth, and I somehow got the notion that a part of that new navy would be built on the Pacific coast. I began trying to interest the trustees of the Risdon Iron Works in my ideas, pointing out to them what I saw coming, and endeavored to show them the necessity of moving their works to the water front, providing the necessary ground and facilities for steel shipbuilding on a moderate scale; but I could not get them to see things as I saw them, and as neither they nor I could change each other's opinion as to the necessity of a shipbuilding plant at San Francisco, I was forced to try the possibility of interesting others in my project.

There were a good many friends of mine with money who had confidence in my ideas relative to shipping matters, so I worked my project up amongst them. A site for a shipyard and dock was selected at Sausalito and preliminary arrangements were made, and it looked to me in the summer of 1882 as if I should be able to start a modest shipbuilding and marine engineering establishment in the quiet shelter of Sausalito Bay; but it was not so decreed. One day a mutual friend of Mr. Irving M. Scott and myself made an appointment with me to call on Mr. Scott that evening, which I did. We had a long conversation on my ideas of the future prospects for shipbuilding and engineering on the Pacific coast; he knew of my efforts to form a shipbuilding and engineering company and told me that the same thoughts had come to him, that the prospect for general engineering was not so bright as it was in Bonanza days

and then suggested that it might be possible to interest Prescott Scott & Co. in my proposition if I could carry my friends into it. We parted with the understanding that he should consult with his partners in regard to the matter and I should see if my friends would join with the Union Iron Works in carrying out my proposition. I found most of my friends willing, though some would not join with Mr. Scott. Finally, however, matters were arranged, a valuation was placed upon the Union Iron Works tools, etc., at the corner of First and Mission streets, and an arrangement was made that a company should be formed to be named the Union Iron Works, to take over the business of Prescott Scott & Co. and the land they owned at the Potrero and establish there an engineering and shipbuilding plant suited to the needs of San Francisco Harbor.

When this work was begun it had not many friends outside of those who had put their money into it; disaster was predicted by all who pretended to know anything about engineering or shipbuilding, and for some years the prospect was not bright to those on the inside; but they had strong hearts and never let their fears reach the outside world. Four or 5 years after the works were established the new navy began to assume definite shape, and we succeeded in getting one of the first 3 cruisers ordered, the *Charleston*, and not long after the *San Francisco.* Twenty vessels of the United States Navy have been built at the Union Iron Works, at a cost of about $32 000 000, and other vessels costing over $8 000 000. An average of about 3 000 men have been employed during the 22 years the works have been in operation, and nearly $30 000 000 have been paid in wages, including all repairs and general engineering work. Nearly 3 years ago these works were absorbed by the United States Shipbuilding Company and the original owners disposed of their interests to the promoters of that unfortunate concern, out of whose wreck Mr. Schwab saved the Union Iron Works. I can follow its history no further, as my connection with these works terminated with the advent of the man Mr. Schwab has placed in command. I shall, however, always be proud of any further success that may come to the works into which I have put the best of my professional life.

There is a condition that the technical man who labors long in one line of work is very apt to fall into, and which my present experience enables me to speak knowingly upon; that is where a man practically loses himself and is lost also to others in his work. For 22 years I had given myself up entirely to the

work as I found it at the Union Iron Works, going from my home every day direct to the works at the Potrero; thus I was never seen in the city in the daytime, and those who knew me as a familiar business figure in the main business streets of San Francisco at first missed me, then gradually forgot me, except as they heard from time to time what was going on at the works. When I had to begin again this year to look for the people who had been my friends so many years ago I found myself in a strange city and among people who hardly remembered the friends I was seeking for, and while many knew my name and something of my work and reputation, yet I have lost my hold on the active men of to-day because I had lost myself and all my friends in the deep grave I had dug for myself in the Potrero. We want to love our work and put all our heart and soul into it, but we must not allow ourselves to be utterly lost in it, for I am finding that after being buried for 22 years in a comfortable shipbuilding and engineering grave, the necessary resurrection is a sort of a Rip Van Winkle return to places where I have long been forgotten. It is one of the evils of our profession that he who is able to accomplish anything worth while in it runs the risk of losing himself entirely in the effort. This is partly the result of the technical education that engineers receive, which absorbs much of the time usually devoted by young men in mercantile pursuits to social intercourse. In early life the engineer gets entirely absorbed in his profession, the very language of which is an unknown tongue except to his professional friends. The technical man gradually becomes self-contained; he is not understood in the society in which he should move, so, late in life, when he needs companionship other than that of the shop, and tries to get into the place in life that he should have always occupied, he finds that no place has been reserved for him and that he must either go back to his old grave that fitted him so well, or industrially set about digging a new grave, probably to die in the effort.

It is this intense struggle that never ends with the engineer if he is to keep abreast with the progress in engineering science, that renders him such a dreary neighbor and chills the social atmosphere all about him; nor do I see any salvation unless he is willing in early life to cultivate more than he ever has done the social habit, and to be able to take delight in the beautiful things around him, to see more in a waterfall than so many horse-power, to be intimate with the things people generally like to see and hear about. We boast very much about the vast

achievements of modern engineering, and rightly, too, but it might not be easy to sum up what the development of engineering has added to the sum total of human happiness. When I look back upon my own engineering experiences I do not find anything that looks now very noble or really worth a man's putting his life into, although a lot of it may have been useful enough at the time. I see only a confused mass of iron beams and steel shafts, hear only the din of wheels and the roar of steam, with here and there a little gleam of something better, and when my memory catches these little bright spots in the picture I find that these were the days that I escaped from engineering and with the wife of my youth got away from the clang and the clamor of these man-made forces, and for a little while crept into the bosom of mother nature, listened to her soothing music, heard the beating of her great heart and rested happy in the thought that I was, after all, one of her children who had tired himself out in fighting her forces. It is a comfort to be able to recall the times and places wherein I came nearest to being happy and to know that these spots are never closed to those tired of the struggle with stubborn circumstances, and it may be that the next hole I creep into will be among the beautiful Santa Cruz mountains. No, it will not be a hole, but "Loma Linda," the hill beautiful, and to such a place, if I get there, it will be my delight to draw many a weary technical that he may learn his child lesson that life is vastly more than an engineering problem.

# ASSOCIATION

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## THE PRESENT STATUS OF THE TURBINE AS APPLIED TO MARINE WORK.

BY HERBERT C. SADLER, MEMBER OF THE DETROIT ENGINEERING SOCIETY.

[Read before the Society, January 26, 1906.]

THROUGHOUT the history of shipbuilding, the attainment of speed, whether high or low, has been one of the fundamental requisites of every design. Depending, as it does, upon so many other conditions, it may not be out of place to repeat, in a general way, the problem that the naval architect must solve.

A floating structure is to be designed which will carry, besides its own weight, a certain weight of cargo, must move at a certain speed for a certain time, *i. e.*, must have a certain weight of machinery and fuel and, finally, must carry this total burden upon a certain draft of water, and do so with safety. It is evident, therefore, that the question of displacement or weight is one of the primary conditions of design.

A discussion upon the resistance of ships is beyond the scope of this paper, but it may be observed that, in general, the less the weight of a vessel the greater the speed obtained with a given horse power. Attention may also be called to the fact that whereas, in high-speed vessels, the weight of machinery and coal may be from 30 per cent. to 50 per cent. of the total displacement, in one of the cargo or intermediate type, this will range from 5 per cent. to 20 per cent. This latter consideration has a very important bearing upon the type of propelling machinery that should be adopted in any given case, and, therefore, immediately affects the subject of this paper.

The requirements that should be fulfilled in any marine propelling instrument are necessarily diverse, depending upon the particular trade or occupation of the vessel. There are, however, certain broad conditions that should be fulfilled by all.

The first and most important is that of *reliability;* this term being taken to mean that the engine will run at its full power for long periods of time with minimum risk of breakdown. The modern marine engines of the ocean liners are prominent examples of what can be done in this respect; but it should be borne in mind that perfection is impossible of attainment, and occasional accidents, necessarily unavoidable. In the merchant marine the failure of the machinery means a loss of time and, hence, money, sometimes a considerable amount, if the vessel is not under control. In war vessels the failure of the machinery at a critical time may turn what would otherwise have been a victory into defeat. Even in pleasure crafts an accident to the machinery may sometimes be accompanied by serious complications. In all, however, the danger of total loss is increased if the vessel be rendered helpless through the breakdown of her machinery.

The second requirement should be one of *economy.* This question is brought home to the naval architect and ship owner more forcibly than to any other designer or power user. From the naval architect's standpoint economy means that a smaller weight of fuel and water is required and hence a saving made in weight and power. To the owner economy not only means a reduction of running expenses, but also decreased first cost, because a smaller vessel may be designed to do the same work as a larger and less economical one.

In war vessels economy means many things, among which may be mentioned increased fighting power or protection, increased speed, or increased radius of action at the same speed.

The third condition should be one of *adaptability* to conditions of propulsion and maneuvering. The almost universal propelling instrument is now the screw, exception being made of of the paddle wheel, the application of which is limited to special types of vessels. The marine engine, therefore, must be capable of running at fairly high speeds of revolution, but the screw propeller again sets an upper limit upon the revolutions beyond which it is undesirable to go. When the phenomenon of cavitation appears, the efficiency of the screw falls off rapidly, and hence very high speeds of revolution are inadmissible. High speed is also accompanied by small diameter of propeller, the

diameter varying inversely as the revolutions. Small propellers are, in general, less efficient than large ones, but there are some compensations in the way of better immersion in cases of light draft and in a seaway, which, to a certain extent, counteract some of the disadvantages.

Another condition of importance is that of maneuvering. A marine engine should be capable of being stopped, started and reversed without difficulty, and by the simplest possible means. In certain cases where the service requires that the vessel should make a number of stops at short intervals, this condition is of primary importance.

In war vessels, also, maneuvering qualities require special attention; but in the case of the average merchant vessel whose trade requires long periods at full speeds and only short ones of backing and handling at each end of a voyage, the above condition does not occupy such a prominent place.

The fourth condition, and one to which attention has already been called, is one of *weight*. The weight per horse power developed should be, in a marine engine, as small as possible consistent with good design. Here again the importance of this depends upon the conditions of service and type of ship; for in cases where the weight of engine is only say 5 per cent. of that of the total vessel, a small percentage saving does not appreciably affect the result; whereas in those cases where this weight is in the neighborhood of 25 per cent. of the total, even a small percentage saving may be accompanied with considerable advantages.

Closely connected with the above is the question of the space occupied and general dimensions of the engine. In a large majority of engines, any saving in space occupied by machinery is a distinct advantage; while in war vessels in particular, the necessity for protection demands an engine whose dimensions in the vertical direction are not excessive.

The final condition and one to which particular attention has been paid in the past few years, is that there should be no unbalanced force tending to produce vibrations when the engine is running.

With this brief résumé of the prominent conditions to be fulfilled by a marine engine, let us proceed to consider in what respects the steam turbine is suitable and wherein it falls short of the requirements.

There are two principal types of turbines, known respectively as the impulse and reaction turbine. These are distinguished by

the pressure existing in the clearance spaces between the guide and rotating blades. If this pressure is greater than that of the steam as it leaves the rotating blades, the turbine is said to be of the reaction type, and if equal the impulse type. There are many other classifications, but at present we need only consider those that have been used to any extent in practice.

As representing the two systems, the De Laval and the Parsons may be said to be typical. The De Laval turbine has one practically insurmountable difficulty, so far as its application to marine work is concerned, and that is its high speed of revolution. In order to bring this within reasonable limits it is necessary to introduce gearing. The high speed at which this gearing must run causes the marine engineer to pause before installing an engine of this type; in fact, high-speed gearing is a method of transmission of energy that should never be used in marine work.

In the Curtis turbine, which is practically a combination of the two systems, *i. e.*, alternate pressure and velocity stages, the number of revolutions has been materially reduced. This turbine, although extensively used on land, has had, up to the present, only a limited application in marine work, so that experience with this particular type is somewhat lacking. There seems to be no reason why, with experience, the Curtis turbine should not be a success when applied to ships.

The success of the turbine in its application to marine work has so far been due entirely to Mr. Parsons, and, as the experience with this type of turbine is the greatest, the remainder of the discussion will be devoted to the application of this particular type.

Taking the conditions previously discussed, in order, the first requirement laid down was that of reliability. In any type of machine, one measure of the risk of breakdown is the number of moving parts. Other things being equal, a large number of joints, moving parts, rubbing surfaces, bearings, etc., is accompanied with a greater chance of stoppage of the whole machine through the failure of one, than where these are reduced in number. In the reciprocating engine the number of parts is unavoidably large, and sometimes an insignificant breakage or overheating may cause a temporary stop. From this point of view the turbine possesses a great advantage in that, so far as the engine itself is concerned, practically the two main bearings are all that require attention. With the present system of forced lubrication this difficulty has been almost eliminated.

The perfect balance and uniform twisting moment, possible with the turbine, also play a somewhat important part in this connection. Up to the present, experience with the turbine in marine work over very long periods has not been possible; but, judging from vessels already running, notably the *Turbinia*, the first vessel to be installed with her present turbines in 1896, and also from the performances of similar land engines, there seems to be no reason for apprehension that the turbine should be inferior to any other type of engine. Certain difficulties have, no doubt, occurred, which with a new type of engine it was almost impossible to foresee, but once these are known their solution should not offer any serious difficulties. Attention has also been called to the gyroscopic effect upon the bearings, when a vessel is in a seaway or turning; but Mr. Parsons has pointed out that in the case of the *Cobra* at maximum speed and in the worst possible sea, these forces would not amount to more than one half of the normal weight upon the bearings. In certain types of turbines, notably those of the impulse principle, the erosion of the blades is liable to cause trouble. In the Parsons type, where the steam velocities are comparatively low, the blades do not give any trouble on this score, at least so far as experience has demonstrated at present.

Closely associated with reliability is ease of repair. To some the multitude of small blades may seem somewhat complex, but in reality this is not so. In the case of one accident, where a number of blades were stripped, the turbine was stopped, the débris removed, and the turbine started again and run for the remainder of the day, apparently without appreciable decrease in power. In all, the accident caused a loss of about three hours.

The first commercial vessel to be fitted with Parsons' turbines was the *King Edward*, built in 1901. Since then this vessel has been run continuously during the summer months and has given entire satisfaction.

No doubt the cylinders of the larger turbines will require considerable attention in design, in order to take care of the expansion. They are apt to distort when heated, especially as the temperature along the cylinder may vary from about 400° fahr. to 100° fahr., thus causing a varying expansion radially. This may lead to increased clearance spaces, but immunity from possible stripping may demand a slight sacrifice of efficiency.

We now come to the second and, perhaps, the most important consideration, viz., economy. So far as direct comparison of turbines of different powers working under different

conditions is concerned, we are met with the difficulty of being unable to determine the indicated horse power of this type of engine. Where it is possible to perform a brake test, such as in land practice, the economy with respect to brake horse power, or horse power delivered, may readily be determined. By making certain assumptions as to the efficiency of the reciprocating engine and applying these to the turbine, we may obtain a quasi-indicated horse power.

It should be noticed, however, that this is not a satisfactory method, and, so far as ships are concerned, a better measure of economy would be the amount of water or coal consumed per mile or hour at different speeds. For definite information as to the amount of water consumed, we must refer, in the first place, to experiments upon land installations.

The results of a series of tests * upon a 400 kw. and a 1 250 kw. machine, built by the Westinghouse-Parsons Company, of Pittsburg, show that the consumption of dry saturated steam per e.h.p. hour at full load was about 14.5 lb.; and at 50 per cent. and 160 per cent. load the consumption was about 17 lb. and 15 lb. respectively. With 190 degrees of superheat, the consumption at full load fell to about $11\frac{1}{2}$ lb. per e.h.p. hour.

On the assumption of 94 per cent. efficiency, these figures would give from 14 lb. to 13 lb. per i.h.p. hour under ordinary working conditions with dry saturated steam. For a good average triple expansion engine under similar conditions, the consumption in all probability would be from 12 lb. to 15 lb., so that from this point of view the steam consumption of the turbine compares favorably with the best reciprocating engine practice.

It is, however, when we come to use superheated steam that the turbine appears in a more favorable light. The economy due to superheated steam is too well known to need any discussion here, but reference is made to the effect of superheating shown in the above figures.

From the results of tests made upon some Westinghouse-Parsons turbines,† the statement has been made that for every 100 degrees of superheat there is a corresponding decrease of 10 per cent. in steam consumption.

No doubt there is a corresponding gain in the reciprocating type of engine, but this fact should be borne in mind, that the

* See paper by F. Hodgkinson, Am. Soc. Mech. Engrs., 1904.

† See paper by I. R. Bibbins, St. Louis Convention of the Am. St. Ry. Asso., October, 1904.

mechanical difficulties resulting from the use of highly superheated steam increase rapidly with the degree of superheat. The principal difficulty lies in the proper lubrication of the internal rubbing surfaces, such as valve faces, pistons and cylinders, where high-temperature steam is used.

In the turbine, however, there is no need of any internal lubrication, and high temperatures do not materially affect the working of this type, provided difficulties due to expansion do not occur.

In a similar manner the gain due to the use of higher vacuum may be represented as varying from 3.5 per cent. to 4 per cent. for each 1 in., depending upon the load. In marine work, reduced power is generally accompanied by decreased revolutions, and as is generally known the efficiency of the turbine falls off considerably under these circumstances. Although data are somewhat lacking upon this point it seems reasonable to suppose that at, say, half power and half the usual number of revolutions the increase in consumption per h.p. hour should not exceed from 40 per cent. to 50 per cent. of the normal amount.

In general, the amount of time at which a vessel is running at reduced speed is exceedingly small, except in special cases, such as war vessels. In these, special means for increasing economy have been devised and will be discussed under the next heading.

From the point of view of economy, therefore, the turbine should show as good results as any other type of engine, especially when its adaptability to the use of superheated steam is taken into consideration.

Before leaving this topic, reference should be made to experiments with exactly similar vessels whose only difference lay in the propelling machinery.

In 1904, the British Admiralty conducted an exhaustive set of trials upon the *Amethyst*, a cruiser of 3 000 tons, fitted with Parsons turbines, and three exactly similar vessels fitted with reciprocating engines. A full report * appeared in *Engineering*, from which the following is taken: Originally up to a speed of 14½ knots, but since certain improvements in connection with the auxiliaries, to a speed of 10 knots, the reciprocating engine has the advantage so far as steam and hence coal consumption are concerned; but above this speed the turbine has the advantage. At 18 knots the reciprocating engine required 24½ per cent., and at 20 knots 40 per cent. more water than the

* See "Engineering," London, November 18, 1904.

turbine. Although some of this difference might be traced to the boilers, the actual amount cannot be great as the heating surface and grate surface were practically the same in all ships.

In the full-speed trials the advantage of the turbine became more apparent; the maximum speed obtained by the reciprocating engine being 22.1 knots, as against 23.63 by the turbine engined vessel, a gain of 1.53 knots, or 6.9 per cent. This is the more remarkable seeing that the boiler installation is the same in all, and the higher speed in the turbine vessel was obtained with slightly less air pressure in the stokehold.

One other case has occurred where direct comparison between reciprocating and turbine engines has been possible. The Midland Railway Company, of England, in 1904 built four vessels, two of which were fitted with four-cylinder triple-expansion engines and two with turbines. This experiment is all the more interesting seeing that one of the turbine vessels is practically the same in all details as the reciprocating type, while in the other full advantage has been taken of the saving in weight due to the turbine, of putting this extra weight into larger propelling machinery.

The vessels were designed for a speed of 20 knots, and the following figures confirm those previously quoted:

From 14 to 20 knots the turbine vessel shows an advantage in steam consumption; between 19 and 20 knots the decrease in consumption is about 8 per cent. in favor of the turbine vessel exactly similar to the reciprocating type, while in the other case, where full advantage was taken of the turbine this figure amounted to 14 per cent.*

From the speed point of view there was also a corresponding gain, the turbine vessels obtaining fully one knot higher speed. An analysis of the results of a number of actual runs under service conditions shows that for the same speed the saving in coal in favor of the turbine amounts to about 9 per cent.; or for the same coal consumption the turbine vessel could be run at a speed of 20.3 knots as against 19.5 knots in the vessel with reciprocating engines.

The Cunard Company is about to carry out a similar set of experiments with two large ocean vessels, the *Caronia* and *Carmania*. These vessels are 678 ft. long, 72 ft. broad and 52 ft. deep, and displace about 30 000 tons. The *Caronia* is already running and developed 22 000 i.h.p. at 19½ knots speed on trial.

* See paper by William Gray, Inst. Naval Architects, London, July, 1905.

The *Carmania* has already made several trips and another direct comparison on a large scale will soon be available.

We now come to the third requirement, viz., adaptability to conditions of propulsion. From the previous discussion, and from the number of vessels already equipped with turbines, the question of the general adaptability of this form of engine is beyond argument. There remain, however, certain conditions which need consideration. Compared with reciprocating engines turbines possess the quality of a relatively high speed of revolution, and it is this consideration which effectually bars certain types from marine work entirely, and places a limit upon the application of others. High speed of revolution is necessarily accompanied with small propellers, which in themselves are not so efficient as the larger ones. When we come to large vessels, the actual size of the propeller plays an important part in the general handling and working of the vessel. Let us consider the principal types of vessels in the merchant service. These may be divided into the cargo boat of slow speed, the intermediate cargo and passenger with moderate speed, and the purely passenger or high-speed type. In the purely cargo boat not only is the power small relatively to the vessel, but also absolutely. For example, a large ocean freighter of, say, 500 ft. in length, and say, 17 000 to 18 000 tons displacement, would not have engines of more than say 3 500 i.h.p., or about the same as that estimated for the *King Edward.* The diameter of the center propeller in this case was 57 in., and the two outside ones slightly less; the revolutions being 505 and 755 respectively. Such small propellers are evidently unsuited for the case in point, and, if the speed of revolution were reduced so that a propeller of larger diameter could be employed, the diameter of the turbines would have to be increased, with the result of little, if any, saving in weight and certainly decreased economy over the ordinary type of engine. We are forced, therefore, to this conclusion, that where the machinery installation or power is small relatively to the vessel, there is no advantage in the use of the turbine, but rather the opposite.

In the intermediate and fast passenger types the conditions just discussed do not hold, as in these cases large or fairly large powers are required, which naturally entail the use of larger propellers, even though the revolutions be kept the same as in the smaller engines.

The one serious drawback that the turbine possesses is its inability to reverse. Although in most cases, in the merchant

marine, an engine is moving ahead for about 99 per cent. of its time, yet the condition of reversibility must be met. In all present arrangements a special reversing turbine is fitted, usually at the end of the low pressure, and runs *in vacuo* when the main turbine is running ahead.

The objection is sometimes heard that turbine vessels cannot be stopped as quickly as those of the ordinary type, and to a certain extent this is true with many vessels. The fact should be borne in mind, however, that the time required to bring a vessel to rest depends largely upon the power exerted, and if sufficient backing power be supplied there is no reason why the turbine vessel should not be as handy as the ordinary type. The objection is, however, a real one, for while in the case of the reciprocating engine the full power is always available for backing, in the case of the turbine, full power in the astern direction would mean a large additional weight and the carriage of a useless engine for the greater part of the time.

Certain experiments upon this question have been performed which tend to show that even with moderate backing power the turbine vessel is fairly handy.

Torpedo boat No. 293 of the French navy, 130 ft. long, displacement 94.6 tons, brought to rest from a speed of 20 knots in 4½ times her own length, or in 585 ft. Channel steamer *Queen*, 323 ft. long, brought to rest from a speed of over 19 knots in 2½ times her own length, in 1 min. 7 sec. Steaming astern, she attained a speed of 13 knots. Channel steamer *Manxman*, 330 ft., brought to rest from full speed (about 22½ knots) in 1½ min.

In war vessels the conditions as to operation at reduced powers and maneuvering are much more severe than those which obtain in the merchant marine. Except in special cases, a warship is seldom called upon to develop her full power after she has completed her official trials. Here the turbine as ordinarily fitted for full power would prove undesirable from reasons of economy.

One method of overcoming this difficulty was that adopted in the destroyer *Velox*, where two small triple-expansion reciprocating engines were connected by detachable couplings to the low-pressure turbines. The steam after passing through these engines was led into the low-pressure turbines and thence to the condenser. This arrangement is undesirable both from an engineering and operative point of view and has since been discarded in favor of the entire turbine installation.

In the *Amethyst* two small cruising turbines are permanently attached to the main low-pressure turbines. At reduced powers the steam first passes through the cruising turbines and then through the main turbines to the condenser, thus giving a large range of expansion. For intermediate powers the steam is admitted first to the intermediate cruising turbine, then to the main high-pressure turbine and so on to the condenser. For full powers the auxiliary cruising turbines are cut out. This arrangement possesses all the flexibility that can be desired, and if reference be made to the steam consumption curves, it will be noticed that these compare favorably with those of the reciprocating engine.

The question of economy at reduced powers is therefore not such a serious matter as one would suppose at first sight; and, in this connection, it is interesting to note that similar arrangements have been made in the vessels of the Russian volunteer fleet: the reciprocating engines in these vessels working as quadruple at ordinary speeds and triple at the higher speeds required on government service.

In connection with the question of weight, there is no doubt that the turbine possesses an advantage over the reciprocating engine. In the case of the Midland railway boats, referred to above, the reciprocating engines, shaft and propellers weighed 280 tons, on the turbines 195 tons, a difference of 85 tons, or 30 per cent. There was also a saving in hull construction weights of about 30 tons, making a total saving of 115 tons.

| | Reciprocating. | Turbine. |
|---|---|---|
| Boilers | 460 | 390 |
| Engines | 210 | 160 |
| Shafting and propellers | 60 | 25 |
| Total | 730 | 575 |
| Speed | 21.9 Knots | 22.3 Knots |

Even in the foregoing figures full justice is not done to the turbine, when the speed is taken into consideration.

For the same weight of machinery in the case of the *King Edward* the speed of the turbine boat was 20.5 knots, as against 19.7 probable speed, if reciprocating engines had been fitted, or a gain in horse power of about 20 per cent.

In the case of the cruiser *Amethyst*, the weight of machinery was practically the same as that of the reciprocating engined

ships, viz., 530 tons. The speed of the *Amethyst* was, however, 23.63 knots against 22.1 for the other vessels.

| | Reciprocating. | Turbine. |
|---|---|---|
| Engines and boilers | 537 | 535 |
| I.H.P. | 9 900 | (14 000)? |
| Speed | 22.1 | 23.63 |

For the same speed and displacement there would be a saving of about 155 tons, or nearly 30 per cent., on the weight of machinery alone. This would also be accompanied by less coal and water, or if these were increased so as to keep the total weights the same, there would be a corresponding increase in radius of action.

With regard to floor space occupied, there is nothing to choose between the reciprocating engine and the turbine. In space taken up in the vertical direction, the turbine has a distinct advantage, although in the merchant marine this may not always be an unmixed blessing on account of the tonnage laws.

The situation may, therefore, be summarized briefly as follows: So far as reliability is concerned, there seems to be no reason why the turbine should be inferior to the reciprocating engine; while from the point of view of economy and speed, the turbine has shown itself in many ways superior. At very low speeds, however, the reciprocating engine is superior in economy of steam, but against this the turbine requires less oil and a slightly less engine-room staff. The turbine in its present state is not suitable for all classes of ships. Where the speed is high or fairly high, that is, in passenger and intermediate types, war vessels and yachts, it may be used to advantage; but in slow cargo vessels where the power is small relatively to the size of ships, and for those vessels which require to be started and stopped at frequent intervals, the turbine is not suitable. From the weight point of view the turbine is certainly superior to the reciprocating engine of the same power, especially in the case of ordinary high-speed vessels. It possesses also the advantage of being perfectly balanced, and hence the vibrations of the vessel may be considerably reduced. From figures available, the cost is slightly in excess in the case of the turbine, but as the speed of the vessel is usually greater, this is more apparent than real. So far as space occupied is concerned, there is little to choose between the two, the turbine having the advantage so far as height is concerned.

In conclusion, it may be interesting to note the number of

vessels built and building, in which the turbine in some form, although mostly of the Parsons type, is employed. In the merchant marine there are some forty-three, ranging in size from small yachts to the new Cunard vessels which will have in the neighborhood of 65 000 i.h.p. Five naval vessels have been built and twenty-one are building, making a total of some seventy-eight vessels in all.

## ANNUAL ADDRESS.

By Ernest W. King, President of the Montana Society of Engineers.

[Read before the Society at Lewistown, Mont., January 13, 1906.]

To the Members of the Montana Society of Engineers, Lewistown, Mont.:

*Gentlemen*,— Another year has rolled around since our last annual gathering, and it is certainly a great pleasure for me to see the contented and prosperous look on so many of the old-time faces that I see before me, and to know that Father Time has dealt so leniently with you all. But when one stops to think of the quiet and simple life led by an engineer, his abstinence from the use of all intoxicating beverages or stimulants, except at annual meetings and in emergency cases, and of the close touch that the very character of his work brings him into with nature, it is not to be wondered at that so many of the old faces that I see before me have such a youthful appearance.

It is also very gratifying to see so many of the younger members of the profession with us here to-day, and it is to be hoped that they will profit by the example of strict honesty, sobriety and close attention to business that has been characteristic of the older members of this society, and that their works in the future upbuilding of the great state of Montana will be recorded with pride in the records of this society and the future history of our beloved state as have been the records of the work of the older members of this society; for it is a matter of history that about all of the great engineering ventures in the state, such as the locating of the principal railways, the building of the large smelters and refineries and the great mining plants, the dams and electric-power plants and the great irrigation schemes that are bringing Montana so fast to the front, have been designed and brought up to their present high state of efficiency by members of this society.

The society has been visited but once by the grim reaper, Death, during the past year, and we have been called on to mourn the loss of our esteemed brother, E. R. McNeill, one of the old-time members of the society and one of the pioneers in railroad work in this state. At a regular meeting of the society,

held December 9, the following resolutions were unanimously adopted:

*Whereas*, God in his providence has removed from our midst Brother E. R. McNeill, a member of this society, now, therefore, be it

*Resolved*, That in the death of Brother McNeill this society has suffered an irreparable loss. His sterling qualities of head and heart were well known to his intimate friends, and his conscientious discharge of every duty intrusted to him is testified to by his employers, as well as by those associated with him on engineering work.

During a long period of active service on railroad engineering in Montana, Mr. McNeill was known as one of the most thorough and painstaking engineers, on some of the most difficult work ever executed in Montana.

"*Resolved*, That this society shall express, by these resolutions, its sincere sorrow on the death of Mr. McNeill, and these resolutions shall be spread upon the minutes of the society and a copy forwarded to his bereaved family.

Finley McRae,
Wm. F. Word,
Frank L. Sizer,
*Committee.*

Owing to the fact that a number of railroads are heading toward Montana, there is a great deal of secrecy maintained by all of the railway companies as to the work they are doing or contemplate doing, and it is very hard to get any actual facts as to future construction work, but it is safe to presume that there will be something doing in Montana for the next year or two in the way of railroad building, as well as in a great many other lines.

One of the engineering features in Montana to-day that bids fair to outrival all others and do more for the general upbuilding of the state, is that of irrigation, and we will take that for our starting point.

## Irrigation.

Nature has provided Montana with several million acres of rich soil that is suitable for raising all kinds of grains and cereals, and she has also provided abundant water to irrigate every foot of this land, but she has shown the same good judgment in this that she has in other things. The precious and other minerals have been placed deep in the bowels of Mother Earth and in very inaccessible places, so that it requires a great amount of money

and continuous labor of a vast army of men to extract them and convert them into mediums of exchange and useful articles for the benefit of man.

She has placed the land and water at the disposal of man, but she has so located the streams in the mountains that it takes a large amount of money and the labors of a vast army of men to bring the waters to an available point so that they may be used to the best advantage on the land. All of this work was done at first by enterprising individuals, but it was soon found that no one individual or company of individuals had sufficient capital to handle the larger irrigation enterprises, and that it could not be done without the coöperation of our national government. This coöperation was hard to get, as nearly all of the eastern senators and representatives were not in favor of expending large sums of money in reclaiming what they designated as parts of the great American desert, or lands that were only fit for the home of the rattlesnake and the howling coyote. But the indomitable perseverance of our western senators and representatives won out in the end and appropriations have been made for preliminary surveys and for the construction of some of the larger enterprises, so that it is almost an assured fact that within the next ten years there will be over one million acres more land under ditch than there is at the present time.

Up to the present time the government has under consideration seven different irrigation projects in Montana, and two of them have been accepted by the Secretary of the Interior and are now in course of construction. The two now in course of construction are the Lower Yellowstone and the Huntley canals.

The water for the Huntley Canal is taken direct from the Yellowstone River near Huntley, and at the head gates will have a capacity of 400 ft. per sec. For the first 2 miles the canal follows along the Huntley bluffs, requiring three tunnels with a total length of 1 500 ft., and at a point 14 miles from the head gates there is a drop of 33 ft. where power can be developed to irrigate 4 000 acres above the line of the canal. This, however, will require an additional canal about 6 miles long. The total length of the main canal will be about 30 miles, and it will irrigate over 30 000 acres.

### Lake Basin.

Preliminary surveys have been under way for the past three months for the lake basin. This basin is about 25 miles north of Billings and comprises over 200 000 acres of good land.

### CLARK'S FORK.

The field work has been completed for this watershed and it is expected to irrigate about 75 000 acres. The lands to be reclaimed lie principally on the left or west side of the stream and extend from Yellowstone River to the Wyoming line.

### MADISON RIVER.

This scheme contemplates taking the waters from the head of the Madison and Jefferson rivers and irrigating all of that section between Three Forks and the Prickly Pear Valley, and would cover over a quarter of a million of acres. The field work on this project is about completed, and by March 1 enough data will be available to determine the feasibility of the scheme.

### MILK RIVER.

The field work has all been completed on the Milk River project and has been approved by the Secretary of the Interior. This scheme contemplates the construction of a large dam at St. Marys Lake, using the lake as an immense storage reservoir, and conducting the waters from the lake by canals to the head waters of the Milk River, and in turn the waters will be taken from the Milk River to large natural reservoirs so that all of the flood water can be stored in the spring and made available during the irrigation season. The Milk River will be used as a natural canal for carrying the water, and numerous canals will be taken out of the river to irrigate the various tracts of land adjacent thereto. It is estimated that this project will reclaim over a quarter of million acres of land.

### SUN RIVER.

Surveys have been completed during the past season on the upper Sun River, about 40 miles west of Great Falls, and several different canal lines are being considered. It is intended to take the water from the river near the mouth of the canyon out in canals on each side of the river, the one on the south side to extend about 50 miles southeast across the Fort Shaw Indian Reservation to the Sun River Bench, just west of Great Falls, and the canal on the north side to extend past Choteau, Freezeout Basin, and down to the high benches near Benton Lake, about 12 miles northeast of Great Falls. A number of good reservoir sites have been located along each of the canals and they will provide ample storage capacity for all of the flood water in the spring of the year.

The construction of the above government works will involve the expenditure of a great many millions of dollars in the next few years, the greater part of which will be paid out for labor to the wage earners of the state and will also provide means for thousands of families to make a good living in the tilling of the soil reclaimed.

The Rosebud Land and Irrigation Company of Forsyth has bought a large tract of land from the Northern Pacific Railway Company and has taken a ditch 25 miles long out of the Yellowstone River, opposite Forsyth. The water is diverted by means of a small dam and concrete head gates, and the ditch will reclaim about 13 000 acres.

The Rancher Ditch Company, a coöperative company of actual settlers, about 25 miles west of Forsyth, has taken out a ditch about 15 miles long and has reclaimed about 6 000 acres in what is known as the Rease Bottom. The head gates are located near Hyshal.

Twenty-five miles east of Forsyth is also another large tract of land, known as the Hathaway Bottoms, that will be reclaimed during the coming summer.

### Billings Land and Irrigation Company.

The Billings Land and Irrigation Campany, a company composed largely of local capitalists, undertook, in 1903, to furnish water to irrigate all of the lands acquired by the state under the Carey Land Act, and also a large amount owned by the Northern Pacific Railway and private owners. The work was started in January, 1904, and has been pushed steadily ever since. State Engineer John W. Wade says: "The Billings Land and Irrigation Company, which has the contract with the state to furnish these lands with an adequate and permanent supply of water, is doing this work of construction in such a way as to insure an ample capacity in the canal to do the work of delivery of all the water that will be needed in the reclamation and cultivation of these lands, and all other lands on the Billings Bench comprising sections alternating with those of Carey selections. I have noted not only the capacity of the canal as it is being built, but have also considered the work as to its permanency. The contracting company deserves special credit for the unhesitating policy with which, manifestly, it proposes to proceed, and ultimately to turn over to the settlers an irrigating plant which, for permanency and stability, is not excelled anywhere in the state. There is a small percentage of fluming

in the length of the canal and this is to be very substantial. The tunnel is in a solid character of rock, and (barring the approaches, which will be so 'thorough-cut' as to make caving very nearly impossible) this will not need the slightest timbering or other interior supports."

The tunnel of which Mr. Wade speaks is one of the features of the work, being a bore through solid rock 1 847 ft. long. It is 7 by 8 ft. in dimension and has a grade of 10 ft. to the mile. The capacity is 500 cu. ft. of water per sec. From the tunnel the water flows into a flume 900 ft. long and averaging 60 ft. in height. It carries a flume 6 by 10 ft. inside. The posts are timbers 10 in. square, extending full length from the flume bed to the ground, where they rest on concrete foundations 3 ft. square and 3½ ft. deep. The posts are of Puget Sound fir.

The main canal is to be 70 miles long, 40 of which have been completed. The water is taken from the Yellowstone just above Clark's Fork, where it is diverted into a ditch 21 ft. wide at the bottom, 44 ft. at the top and carrying 5 ft. depth of water. The irrigated lands lie just north of the Crow Reservation on the Huntley flats, just across the river from the reclamation project of the government service. The big tunnel is just across the Yellowstone from Billings, and the first lateral begins irrigation of the lands about 1½ miles east of the city.

Besides the state lands taken under the Carey Act, the school and university lands and those privately owned, 12 680 acres of land were purchased from the railroad company, the terms of sale making it binding upon the irrigation company to furnish a perpetual and adequate supply of water to settlers purchasing lands designated railroad lands within the tract. Altogether 35 000 acres are in the tract, and tributary to the canal across the river lie 3 000 acres for which the ditch has capacity and which it could cover by the construction of a pipe line.

There are numerous other smaller enterprises being handled by private capital, all of which enterprises will go to swell the grand total of acreage that will be soon changed from a comparative waste or desert to happy and prosperous homes, for thousands and thousands of what our great railroad magnate, James J. Hill, calls the backbone of the country, the Honest Farmers.

## Water Power.

The rapid development in the field of electrical operations during the past few years has probably done as much to bring

Montana to the front as any one industry within its borders. It has made it possible to operate street car lines, factories, smelters, mining plants, pump water for irrigation and even to operate telegraph lines, etc., from sources of power that a few years ago had no commercial value whatever.

There are a number of new improvements in the use of electricity that not only the general public, but a great many engineers are not aware of.

The current for operating the telegraph instruments on the lines of the Northern Pacific Railway, the Great Northern Railway and the Western Union Telegraph Company in Butte and Helena is furnished from the power plant at Canyon Ferry.

Raising water from deep mines is now accomplished by electrical hoists that work entirely automatically, a noted example of this being in a coal mine owned by the Lackawanna Railroad Company. The water is hoisted by a skip that fills and dumps and reverses its motion at the top and bottom entirely automatically, and all that is necessary is to turn on the current and oil the machinery at stated intervals.

Great improvements are also being made in hoisting ore by the use of an electric hoist. Owing to the great variation in power used in hoisting plants, it has been impossible to contract for electrical power at anything within reason, as, for instance, take one of the large plants in Butte, using a 2 000 horse-power hoist; the actual load hoisted would not require over 300 h. p. running continuously, yet it would be necessary to pay for the full 2 000 h. p. if it were bought from any of the power companies. This is being overcome now by using a motor generator set, of which there are a number now in use. The General Electric Company is now installing several of these hoists in Mexico at El Cro for the Mexican Light and Power Company, and they will probably also install two plants in Butte in the near future, one for the M. O. P. Company and one for the Butte Copper and Zinc Company at the Emma Mine.

The method of operating is to have a slow-speed, continuous-current motor, either geared or directly connected to the hoisting drum. This receives its current from a continuous-current generator driven by a motor. The motor generator set runs at a high speed and carries a fly wheel. This fly wheel is of sufficient capacity to operate the hoist for one continuous trip without any power being supplied from the system. The object of the fly wheel is to store up power during nine tenths of the time that the hoist is idle and to give it out during the few seconds

that the hoist requires it. The result is that the power drawn from the supply system is practically constant and the wide fluctuations in current are confined to the connections between the hoisting motor and the generator. The power drawn from the system is, therefore, only a fraction of that required to start the hoist.

The system of control is by regulating the field of the generator, and, therefore, the voltage supplied to the motor on the hoist. This means that only 1 or 2 per cent of the power current passes through the controller and makes it a much more easily handled piece of machinery, and the speed of the hoist can be controlled from full speed to just barely moving. The cost of the motor generator set, fly wheel and motor on the hoist is only about 50 per cent. greater than the induction motor connected direct to the hoist, so that the extra cost of installing is as nothing compared to the cost of power that would be saved by the new method.

The use of electricity for operating rock drills is becoming more and more in favor with mining men, and I believe that within a few years they will entirely do away with the old compressed-air drill that is used so extensively to-day.

There are several types of electric drill on the market now that will do as much work as any of the air drills and with less than one sixth of the power; but so far the breakage and repairs on the electric drill are so much heavier than on the air drill that it has not come into general use; but the Yankee engineer will soon overcome these difficulties.

There are several large water powers now in course of development to be used exclusively for generating electricity and transmitting it a long distance.

### Missouri River.

The Missouri River has already been harnessed at Great Falls and at Canyon Ferry and both plants are taxed to their utmost. A third company has been incorporated, known as the Helena Power Transmission Company, composed practically of the stockholders of the Missouri River Power Company, the present owners of the Canyon Ferry dam. The new company is now building a new dam across the Missouri at a point about 18 miles below the Canyon Ferry dam and about 18½ miles from Helena, just below the mouth of Prickly Pear. The dam will be constructed entirely of steel and concrete, will be 500 ft. wide on the overflow, will have a total width of 900 ft. and 65 ft. height and will back up the water about 17 miles.

There will be over 2 000 tons of steel and 25 000 barrels of cement used in construction and there are now about 300 men at work on the enterprise.

The power station will be first equipped with four main units of 4 000 h. p. each, but the capacity of the plant, when completed, will be 25 000 h. p.

The machinery is all being furnished by the Westinghouse Electric and Manufacturing Company of Pittsburg, Pa., and the steel for the dam is being furnished by the Wisconsin Bridge and Iron Company of Milwaukee, Wis. The total cost of the plant, including the sub-stations in Butte and Anaconda, will be about eleven hundred thousand dollars and the power will be used principally in the mines and smelters of the two last named cities. This work was designed and is being constructed by M. H. Gerry, Jr., a member of this society.

### Madison River.

In the narrow canyon of the Madison River, about 8 miles from Norris, is about completed the largest water-power plant in the state. The dam, which is all completed, is 45 ft. high, 232 ft. long and 98 ft. wide at the base, and backs water up a distance of 4 miles, forming one of the most beautiful bodies of water in the state.

The water is carried from the dam to a point above the power house, a distance of 8 000 ft., through two 10-ft. wood-stave pipes, discharging into a forebay 30 ft. by 60 ft. by 30 ft. deep, excavated from the solid rock. From there it is carried to the power house below by four steel pipes, each 9 ft. in diameter, and delivered to the wheels under a head of 127 ft. The power house is 200 ft. long by 60 ft. wide, and the walls are 30 ft. high. It is built entirely of steel and concrete and will be equipped with traveling crane and all modern appliances for repairs, etc. The plant when completed will have a capacity of 50 000 h. p. The current at the plant will be generated at 10 000 volts and will be stepped up to 40 000 volts and delivered to the distributing station in Butte, at the foot of Montana Street, where it will be stepped down to 2 200 volts for commercial use. The company expects to deliver this power to all points within a radius of 100 miles from its power plant. It has already secured the electric-light and street-car plants in Bozeman and expects to have them operating with its current next month. It also expects to extend its lines to Livingston, Virginia City, Dillon, Whitehall and several other smaller towns,

besides Butte and Anaconda. It also contemplates building an electric railway though Gallatin Valley and up the Flathead Valley, north of Bozeman. This plant was designed by, and is being constructed by, Harry Turner, Max Hebgen and Mr. Craven, all members of this society.

### Bonner.

Hon. W. A. Clark has recently acquired the electric plant in Missoula, and he is building a dam at the confluence of the Big Blackfoot and Hell Gate rivers, a few miles from Missoula, and power will be carried to Missoula from this dam for operating electric lights and street-railway plants.

### Livingston.

A water power is being developed on the Yellowstone, by taking out a ditch about 9 miles long. This plant is expected to develop about 9 000 horse power, and it will be used principally in Livingston.

### Beet Sugar.

The wonderful success made in Utah and Colorado of manufacturing beet sugar has started investigations in all parts of the country as to the adaptability of different soils for raising sugar beets, and by actual experiment it has been found that the soil in several parts of Montana is peculiarly adapted to this work, and especially where the soil can be irrigated by a never-failing supply of water.

The location of a beet-sugar plant was taken up by the enterprising citizens of Billings, and in a very short time they succeeded in interesting with them the owners of three plants in Colorado, and in November, the contract for the construction was let to the Kildy Manufacturing Company, of Cleveland. This is one of the three companies in the United States equipped to build such factories complete. The plant will have all improvements of value in the way of machinery and equipment and will cost over a million dollars. The main building will have a ground area of 380 ft. by 85 ft., and will be four stories high. The " Steffens process " building will be 100 ft. by 80 ft. and the power house will be 150 ft. by 50 ft. The engines will develop approximately 2 500 h. p. All construction will be of steel, concrete and brick, making the buildings thoroughly fireproof.

## Process of Manufacture.

The beets are brought into the factory from the wagons and cars by flumes in which they are floated to the elevators. They are then carried to the top of the building where an automatic scale weighs them and registers the weight. Then they are dumped into the slicers, huge tanks beneath which corrugated knives revolve horizontally. The sliced beets, now called "cossettes" are carried on a belt conveyor to the diffusion cells. Water is forced through the cossettes until all saccharine matter is absorbed, after which the remaining pulp is dumped into silos for use as feed for stock.

The sweetened water passes through various processes to remove the various salts gathered from the soil by the beets. These are dissolved and absorbed along with the saccharine matter in the diffusion process. To remove these the juice is mixed in the first carbonation process with milk of lime, the chemical action precipitating certain of the salts. The liquid is then put through filter presses, from which it passes to a second carbonation where the process is repeated. The juice is then subjected to sulphur fumes and a third filtration. It is then introduced to a quintuple effect evaporator, where the super-moisture is driven off and it is reduced to the proper density for boiling. It is boiled to a sugar grain in vacuum pans, and is separated from the molasses by a centrifugal machine, from which the sugar passes through a drier to the bag. The lime used in the process is burned by the company itself, in order to insure the absolute purity, which is essential; otherwise the quality of the sugar might suffer. About 8 000 tons are used during a season. The experts of the company are now in search of a satisfactory deposit of lime rock on which the Billings factory may depend.

The operation of the factory is to begin October 1, and will continue four months each year. The plant will have a capacity of 1 200 tons of beets daily, producing from 3 000 to 3 500 bags of "A1 Standard" granulated sugar. It will have about 300 common employees, with a payroll of $900 to $1 000 daily. The experts employed in directing the work will bring the daily expense up to $2 500.

The business men and farmers of the Gallatin Valley have also taken the matter up and arrangements have been about completed for the erection of a plant at Bozeman, and with a fair prospect of having one located at Manhattan.

The settlers of the Milk River Valley have not been asleep

during this time, and they claim that they are in a fair way to get a plant located near Chinook or Harlem.

### Railroad Building.

From present indications it would appear that all eyes, especially railroad eyes, are turned toward Montana this year.

The Burlington, or rather James J. Hill disguised as the Burlington, is pushing its survey as rapidly as possible on its line from Billings to Armington, to connect the present terminus of the Burlington with the Great Northern system. The contract has already been let to Mr. La Folette, a relative of Mr. Hill, and he has already begun to form his outfits and get ready to start in the immediate future. So far as can be learned, this line will cross the Yellowstone west of Billings.

The Chicago, Milwaukee & St. Paul Railway has also a number of engineering parties in the field, locating a line through Montana with the intention of going to the coast.

The Montana Railway has a party of engineers in the field locating a line from Forsyth up the Musselshell and past White Sulphur Springs to Helena.

The Soo people are not sleeping either. They have a party of engineers in the field and have taken soundings on the Yellowstone at Sidney for a bridge, and practically have their line located from there to Jordan in Dawson County.

The Northwestern is also in the field with engineers and is gathering data with an eye to building through the state, so that there is a possibility of five different roads being under construction within the next one or two years.

### Mining.

While agriculture will in no distant day be the leading industry in the state, up to the present time and for some years yet to come the mining industry will lead all other industries in Montana, and keep her at the head of the list of mining states in the Union. In my opinion, the state has hardly been scratched over yet, and new districts will be opened up that will surprise even the old-timers in their richness.

In the early sixties, the only tools necessary to start out mining were a pick and shovel, gold pan, six-shooter, supply of grub and lots of nerve, and the only metal looked for was gold in its free state. As the gold was found in larger quantities and at considerable depth to the bed rock, the cradle, the ground sluice and the hydraulic giant were brought into play, but no attempt

was made to save anything except the gold, and the presence of silver and copper, as was the case in the early days of Butte, was considered as a detriment to the workings. But gradually new machinery was brought into play for mining and hoisting the ores from quartz veins and for milling and smelting them to recover their values, and there has been a gradual improvement in the methods used in mining, hoisting, milling and smelting from then to the present time. The modern concentrator has made it possible to handle ores of a very low value by taking out nearly all of the silica and other impurities before it is turned over to the smelter.

The modern dredge has made it possible to recover the gold from the bottom of old river channels and places where it was impossible to think of working without it, and a number of dredges are working in Montana at a profit on old placer workings that yield from five to eight cents per cubic yard.

The cyanide process for treating gold ores has been perfected within the past thirteen years, and has made it possible to treat ores at a profit carrying as low as $1.50 per ton, where conditions are favorable for mining the same, and the use of electricity generated by water power has made very rapid advances in all classes of mining.

There have been no radical changes in any of the methods of recovering values from ores during the past year. Probably the Hancock jig has been one of the simplest improvements in concentrating that has been brought out. In the Butte Reduction Works, three of the Hancock jigs are doing the work of fifty old-style plunger jigs, and with about one twentieth of the power, and at the Boston and Montana Concentrator in Great Falls one of the Hancock jigs does the work of about thirty of the ordinary jigs.

While there have been no large plants erected during the past year for mining or smelting, there are a number of smaller improvements going on all the time.

A new working shaft is being sunk on the Leonard Mine, and is now completed to the 700 ft. level. It is a four-compartment shaft, each compartment being 4 ft. by 5 ft. A new engine has been ordered and the foundation is ready to receive it. The engine will be 32 in. by 72 in. cylinder, capacity 34 000 lb., depth 3 500 ft., using a 1½-in. round rope.

At the Mountain View Mine a new hoisting engine is being installed, made by the Webster Camp and Lane Company, double cylinders 28 in. by 72 in., capacity 21 000 lb., depth

3 500 ft., using flat rope ½ in. by 7 in. A complete new engine house and boiler plant are being put in also.

At the North Butte Mining Company, a new double-cylinder hoist is being installed, double cylinder 32 in. by 72 in., capacity 34 000 lb., depth 3 500 ft., using a 1½ in. round rope.

At the Washoe Smelter at Anaconda, arrangements are being made to use electric power exclusively as soon as the new Missouri River Power Plant is completed. Two big blast furnaces have been installed and started during the past year. These furnaces are the largest of their kind in this country, being 612 in. long by 54 in. wide, and all of the reverberatory furnaces have been changed to the long furnaces which are 112 ft. 6 in., by 19 ft. each in the hearth.

At the Butte Reduction Works the plant is receiving a general overhauling. A new steel converter building, 108 ft. by 211 ft., is being erected to be equipped with the most modern converters made, and everything will be operated by electricity. The new cement and steel stack just completed is quite a novelty and deserves more than a passing mention. The following description was furnished by James Doull, superintendent of construction:

## The Large Weber Steel Concrete Chimney, at the Butte Reduction Works.

For the foundation of this chimney the ground was excavated to a depth of 7 ft. befow the surface, on a level with the water of the Blacktail Deer Creek, and close to the south bank of the creek, the formation of the ground being a natural washed sand deposit. Into this excavation a box was made of cast-iron plates, being 100 ft. square and 3 ft. deep, and into this box was poured molten slag, making a solid block of this size. The foundation was built up by a series of these slag blocks, 3 ft. high, each block being stepped in from the outer edges of the one below 3½ ft., thus forming a stepped pyramidal form. There are six of these blocks, making a slag foundation 18 ft. in depth and 66⅔ ft. square on its top surface. While the molten slag was being poured into the boxes, layers of steel wire rope, chain and T-rail were sewed horizontally through each block, and standing vertically through these blocks of slag and projecting out of the top of the slag foundation, and into the stack foundation base, was all manner of scrap iron and steel which usually accumulates around a smelter, there being 70 tons of this material used. The total weight of the slag foundation is

12 800 tons. On top of this foundation was built the foundation base of the chimney, this foundation consisting of a solid block of concrete, made of Portland cement, sand and crushed slag, being $42\frac{1}{2}$ ft. square and 5 ft. high at its sides and $8\frac{1}{4}$ ft. high in the center. The top of this block was shaped like the frustum of a pyramid. Horizontally through this block of concrete were laid four layers of $1\frac{1}{4}$ in. by $1\frac{1}{4}$ in. T iron, two layers being laid parallel with the sides of the block, and two layers diagonal. Into this network were placed vertically, and in a circle corresponding to the size of the chimney, 500 bars of $1\frac{1}{4}$ by $1\frac{1}{4}$ T steel, these bars being all bent outwardly at their lower ends, forming a network similar to the roots of a tree. The upper ends of these bars projected up out of the concrete base to receive the wall of the chimney. On top of this block of concrete was started the chimney, the walls of the chimney being formed by a unique system of sectional molds. These molds, when coupled together, formed complete rings. Two sets of the molds were used on the inside and two sets on the outside, each mold being $3\frac{1}{2}$ ft. high. When one mold was filled, the lower one was detached and laced on top of the newly filled one, this system being followed to the top of the chimney. When a set of molds or rings was in position, the concrete was elevated in buckets and dumped between the molds and thoroughly stamped all around the vertical and horizontal steel bars, thus bedding all the steel into the wall of the chimney. There were 500 of these vertical bars in the chimney at the base extending up for 25 ft.; each succeeding 10 ft. of height the number used was reduced by 20 bars up to a height of 275 ft., and 30 vertical bars were then used to the top. The vertical bars were lapped 2 ft. at the joints and all joints were made at irregular intervals. From the base to the top, rings of 1 in. by 1 in. T iron were laid horizontally, exterior to the horizontal bars and wired to them. For the first 21 ft. these rings were laid every foot in height, and from this point to the top, every 3 ft. in height. For the first 21 ft. of the height of the chimney, the walls are 18 in. in thickness, and in these walls are two inlets to the chimney, one on each side, each opening 8 ft. by 17 ft. On top of the 18-in. wall starts the double shell of the chimney, the outer shell being 9 in. thick, the inner shell 5 in. thick, the shells being separated by a 4-in. air space, this air space at the bottom being connected with the atmosphere through the outer shell by port holes. The inside shell extends up to a height of $101\frac{1}{2}$ ft. above the base, and the outer shell is offset over the inner

shell as will be noted on the exterior of the chimney. The air space is left entirely open on the inner side of the chimney and the inner shell perfectly free from the outer shell at the top. The outer shell is then carried 7 in. thick to the top of the chimney.

There were used in the construction of the chimney, 60 tons of T steel, 1 500 barrels of Utah Portland cement, and 1 400 tons of sand. The weight of the chimney is as follows:

| | |
|---|---|
| Slag foundation | 12 800 tons |
| Concrete base | 1 000 tons |
| Chimney | 1 475 tons |

The dimensions of the chimney are:

| | |
|---|---|
| Surface area of foundation | 10 000 sq. ft. |
| Area of concrete base | 1 806 sq. ft. |
| Outside diameter of chimney at base | 21 ft. |
| Outside diameter of upper shell | 19 ft. 2 in. |
| Inside diameter at base | 18 ft. |
| Inside diameter at top | 18 ft. |
| Height of slag above surface | 11 ft. |
| Height of concrete base | 8¼ ft. |
| Height of chimney | 333⅓ ft. |
| Total height of chimney above surface | 352 ft. 7 in. |
| Height of chimney above grade at intersection of Montana Street and N. P. tracks | 351 ft. 10½ in. |

Elevation of top of chimney above sea level, 5 791.3 ft.

The top of the chimney is on a level with the following streets of Butte: 60 ft. north of Copper Street, on Main Street; 60 ft. north of Woolman Street on Excelsior Avenue; 11 ft. higher than the elevation at the School of Mines; level with the northwest corner of Montana Street and Quartz Street.

The chimney is the largest and highest concrete chimney in the world, and one of the largest chimneys of its height in the United States. The dimensions of some of the large chimneys in the United States are as follows: Washoe Copper Company, at Anaconda, largest in the world, of brick, 30 ft. inside diameter and 300 ft. high; Metropolitan Street Railway Company, New York City, of brick, 22 ft. inside diameter and 353 ft. high; Clarks Thread Works, Keanry, N. J., of brick, 11 ft. inside diameter, 335 ft. high; Omaha and Grant Smelter, Denver, Colo., of brick, 16 ft. inside diameter, 350 ft. high; Oxford Copper Company, Constable Hook, N. J., radial brick, 20 ft. inside diameter at base, 13 ft. at the top, 360 ft. high; Tacoma Smelting Works, Tacoma, Wash., concrete, 18 ft. inside diameter, 300 ft. high.

The slag foundation was designed by James Doull, of the

Butte Reduction Works, and put into place under his supervision, and was originally intended for a brick stack of the same internal dimensions as the present concrete stack. The concrete base and chimney are the design of the Weber Steel Concrete Chimney Construction Company, of Chicago, and the entire work of erection of same has been under the direct supervision of Mr. Martin Steiler, and certainly stands as a monument to his ability as a chimney builder. The chimney has been tested by instruments as it progressed, and stands perfectly plumb.

At the Kendall Mine, here in Fergus County, there have been installed a 150 h. p. double drum electric hoist and a new seven-drill Fergusol compressor. The new three-compartment shaft is now down 600 ft.

At the Barnes King Mines, electric power has been adopted for operating the mill and compressors, and lighting the mines. The company has recently put in a Sullivan electric diamond drill that is working very satisfactorily.

At the Gold Reef Mines at Gilt Edge, there is now in operation the only roasting plant in the state for roasting ores for treatment by cyanide process, and they have demonstrated that sulphide ores can be successfully cyanided.

## General Outlook.

The general outlook for the future prosperity and rapid growth of Montana has never been brighter. The vast area of agricultural lands that will be reclaimed, the building of beet sugar factories, the increased production of our metal mines, the building of a great many additional miles of railroad, and the opening up of numerous new coal mines, as is sure to follow the building of new railroads through sections where coal is known to exist, will give employment to double the men that are now employed in the state.

My address would not be complete if I did not make mention of one more industry in which we all take pride, and that is the Montana School of Mines. Located as it is, in the heart of the greatest mining camp on earth, with every chance for the students to keep in the closest possible touch with all the latest methods of mining and metallurgy, and with an able corps of professors and a well equipped school, the class of young engineers it is turning out each year is second to no school of mines in the country. I speak from experience in this matter as I have sampled its product by employing several of its graduates, and I have found them to be 100 fine.

## MADISON RIVER POWER COMPANY'S PLANT.

By G. W. Craven, Member of the Montana Society of Engineers.

[Read before the Society, January 13, 1906.]

In 1896, surveys of the Madison River valley were begun near Norris, Mont., and continued for some 60 miles south, with the intention of promoting an electrical enterprise, if the conditions warranted.

This valley extends north and south, and its mountains are very rugged. It is, therefore, not affected by the heat of the sun simultaneously all day over almost its entire surface as is one that extends east and west, and the snow does not melt as rapidly in the first as in the second, so that damaging freshets are not to be feared and immense snow fields are reserved to feed its streams during the otherwise dry period.

The territory drained by the Madison River and its tributaries, available for power purposes, is 2 180 sq. miles. The minimum flow of water is 500 cu. ft. per sec.; average flow is 1 400 cu. ft. per sec.; maximum possibly 10 000 cu. ft. per sec.

The lower canyon, that near Norris, is 12 miles long and has a fall of 256 ft. in the first 8 miles. The fall of the last 4 is of scarcely any value for power purposes.

The geological formation through the canyon is black gneiss. The walls are very precipitous and, in some places, leave comparatively narrow passes for the river. In one of these, which was about 80 ft. wide at the bottom, 1½ miles from the upper end of the canyon, the site for the dam was chosen. By building a dam 236 ft. long and 57.4 ft. high at the deepest place, a reservoir was formed having an area of 4 000 acres, and a storage capacity of 44 000 acre ft., equivalent to 1 916 640 000 cu. ft.

Two years were spent in surveys, locating rights and representing claims; and about the same time in constructing a temporary wing dam and doing other preliminary work, as well as building a good flume, 10 ft. by 16 ft. inside and 1 200 ft. long, to carry water to a power house, from which electrical energy was sent 65 miles to Butte. The available head at this power house was 28 ft.

In July, 1900, the power company was organized and work was started upon a permanent dam which was to be a rock-filled

crib. Bed rock was reached across the river, except for a short distance, where two large bowlders were found. The spaces around these were cleaned as well as possible by means of steel brooms, and then filled with cement grout. The cribs are of large logs, 8 ft. centers, carefully notched together, anchored to the bottom, and driftbolted to each other. The upstream timbers are sawed to give a good nailing face for the vertical sheathing, which was 2-in. plank doubled. The seal is a concrete bed from 8 ft. to 13 ft. deep, 10 ft. wide, in which were imbedded the first logs of the crib and the lower end of the sheathing. The cribs are filled with rock as large as could be handled conveniently with a derrick — many weigh 8 to 10 tons each — and hand-placed smaller rock. All of this was blasted from the adjacent cliff, so that an excellent filling material was obtained near by and, at the same time, the upper part of the channel was widened for a spillway. There is no dirt or sand used for filling.

When this work was about two thirds of its intended height, and 140 ft. long, the company became the Madison River Power Company, with Max Hebgen, of the Butte Electric and Power Company, as supervising engineer. At this time the writer began his duties as engineer with the company.

The new management started active operation February 20, under quite adverse conditions.

The intake of the flume is on the east side of the river and the dam was started on the west side. The remaining space to be filled was, therefore, under from 1 to 6 ft. of ice which had been caused by the extreme cold weather immediately preceding, or was the channel occupied by the flume, through which it was almost necessary to carry water in order that power might be sent to the substation at Butte.

There was no material on the premises or near by, and it was evident that the remaining portion of the dam must be built before high water, or the whole structure would be likely to go out.

The plan of the original company was changed; a third layer of 2-in. sheathing was added to the face, and the base was widened to 92 ft. There are now three steps 8 ft. high and 20 ft. wide, and two steps 5 ft. high and 16 ft. wide. The first step forms the apron, the top of which is several feet above the river bed in some places, but large rocks were placed along its entire length. They did not move this season so far as we know, though the water was not high and the test not severe.

Sawed timber was used in the reconstruction work throughout. When the cribs were high enough for the deck, 10 by 10s were placed 4 ft. centers at right angles to the flow and to these was driftbolted 10-in. deck planking. The east end is a reinforced concrete block, 96 ft. long and 44 ft. high at the deepest place, and in it are the head gates and two 5-ft. square manholes. The top of this block is 4 ft. higher than the flashboards — to be described later — which insures an approach to the gate-operating mechanism even during the highest water.

The spillway over the dam, with the flashboards off, is 140 ft. wide and 10 ft. deep. There is a pipe, 11 ft. in diameter, in the concrete block, placed near the bottom to serve as a waste pipe which will discharge under a head of 28 ft., if need be, in time of flood. The feeder pipe is 14 ft. in diameter through the headblock. This pipe was intended to carry water to the old power house and operate as a pressure line. The large size was desirable, therefore, that a low velocity might be had. A change in plans whereby the power house is to be located 1½ miles down the river, available head 123 ft., has been made and the pipe line will discharge into an open tank. This being the case a high velocity is not so objectionable and the pipe has been drawn in down to 10 ft. in diameter.

Four wooden sluice gates, 3 ft. 8 in. wide and 15 ft. high, control the entrance to the feeder line; three, 3 ft. 8 in. by 12 ft., to the waste pipe. These gates slide in steel guide columns built into the concrete. Their rubbing surfaces are shod with angle iron. The leakage from the four gates controlling the feeder passed through a 2-in. hole with less than 1 ft. head of pressure. They are controlled by means of a hydraulic ram. This enables one man to operate them. They have been opened and closed almost daily since May, 1905, without a single mishap.

The screen bars are ¼ in. by 2¾ in., six to the foot, carried by channel supports.

On top of the wooden deck are the flashboards above mentioned. The frame consists of steel columns bolted to the deck, 20 ft. centers and 10 ft. high in the clear. Between the tops of these are steel girders which serve as a walk and also as a support for the tops of removable columns, 6 ft. 8 in. centers. The bottom of the removable columns rests against a foot-stop and on the top is an arrangement for lifting the column until the bottom end slips past the support, letting the flashboards go down the river, the column swinging out with the top. This method is to be used only in case of a flood so sudden and high that the flash-

boards cannot be moved beforehand, and stored upon the walk across the river. The column can then be put in place with the assistance of a traveling crane placed on the walk.

In the entire dam there are about 175 000 ft. of log, 450 000 ft. of 10 by 10; 13 500 driftbolts $\frac{3}{4}$ in. square by 18, 20, 30 and 36 in. long; 2 250 cu. yd. of concrete; 6 750 cu. yd. of rock and 100 000 lb. steel, making a structure 236 ft. long with a spillway 140 ft. by 10 ft.; discharge pipe 11 ft. in diameter discharging under a head of 28 ft.; and a pipe line feeder, 14 ft. in diameter, discharging under a head of $26\frac{1}{2}$ ft.

From the dam a pipe extends 7 600 ft. to the pressure tank near the new power house. This pipe is 10 ft. inside diameter, built of 3-in. Oregon fir staves. It is encircled by $\frac{7}{8}$-in. steel rods, 12 in. centers at the dam and decreasing in distance to 7 in. at the tank. It is supported every 5 ft. 4 in. by a steel cradle, weighing 375 lb. and is provided with two drain valves and four manholes.

The energy in a body of water 10 ft. in diameter and 8 000 ft. long, moving 8 ft. per second, would, if suddenly checked, rupture almost any pipe that can be built. Again, a sudden demand for power could not be met until the velocity had been increased and water brought 8 000 ft. from the reservoir. To avoid the first condition and eliminate, as far as possible, the second, an excavation was made in the hillside above the power house. This is an open tank; three of its walls are 2 ft. above the reservoir contour, and the fourth wall, which is the north side and also the one down stream, is level with the reservoir; hence this side can be used as a spillway for intermittent discharges during the operation of the plant and yet not materially increase the pressure on the pipe line. This tank also will have a storage capacity of 75 000 cu. ft. whereby this amount of water will be ready for immediate use in case a heavy load should come on.

The east side and north end of this tank are formed by the hillside and are rock. To insure against leakage they will be lined with cement mortar. The south end will be a concrete block through which the 10 ft. pipe enters. Provision is made for a second pipe of the same dimensions. The west wall will be of reinforced concrete, and kept from spreading out by five steel girders anchored to a channel sill at the bottom and tied across the top by means of channels to the hillside.

From this tank, which has gates similar to those in the main headblock, four steel pipes 9 ft. in diameter will lead to the

power house to feed 54-in. center discharge, horizontal, Leffel twin turbines, direct connected to general electric, three-phase, sixty-cycle, revolving field generators, running at a speed of 300 revolutions per minute and generating at 4 000 volts.

The ultimate output of the station will be 10 000 h.p. The energy will be delivered to Butte, Bozeman and other points purchasing electrical power.

# CONSTRUCTION OF A POWER PLANT UNDER DIFFICULTIES.

By Edward C. Kinney, Member of the Montana Society of Engineers.

[Read at the Annual Meeting of the Society, January 13, 1906.]

A company of capitalists from Milwaukee and Chicago had conceived the idea of making fortunes by going into the western country and building an industrial city, buying the land at farm prices and selling it in city lots, and in the meantime building factories that would bring big profits and induce settlers to occupy their lands. The project for manufacturing required cheap and abundant power, and this could be had only by utilizing water power.

The site selected for this magnificent program was at Gothenburg, Neb., a small village on the Union Pacific Railway, and near the Platte River. The company bought seven sections of land around the town and many town lots. They then built a lake covering about a hundred acres of land, and a canal ten miles long to supply it with water from the Platte River.

When this part of the program had been completed, I was called upon to build the power plant, and to conduct the water to it from the lake and from it to the river.

The soil was a fine, brown, sandy loam of the general appearance of brown sugar, and of about the same consistency in water. Underlying this at a depth of from 10 to 20 ft., was a stratum of clean-washed river sand and gravel saturated with water, and extending down to the level of the river bed. From that point down indefinitely were large bowlders and coarse gravel. There is no bed rock within reach in that country, and no rock fit for building nearer than the mountains in Colorado, some 300 or 400 miles away. Bearing in mind the story of the man who built his house on the sand and the rains descended and the floods came and washed his house away, the proposition seemed a hard one.

The power house was located about 1 000 ft. from the edge of the lake in the direction of the river, and at a point where the bottom of the wheel pit would reach the level of the bottom of the river by excavating 25 ft. The length of the tailrace from the power house to the river was about a mile, and the depth of soil would require a great amount of excavation. It was desired

to do this by hydraulic work, or washing with water from the lake. This plan required the wheel pit for the power house to be built first, together with the pipe leading from the lake to the house. It would have been entirely impracticable to do the hydraulic work on the tailrace directly from the lake.

The wheel pit was nearly circular in form, 26 ft. inside diameter and 25 ft. deep, and built of stone laid in cement mortar. The location was first excavated in circular form of sufficient size and down to the level of the water, in the stratum of sand. Then was built in a circular shell or caisson of 2-in. plank placed vertically and 12 ft. high. The lower edges were beveled to a cutting edge with the sharp side out. The planks were fastened by spiking to circular forms that had been prepared and fitted in like shelves. The lower form was made of four courses of 2-in. plank cut in segments of a circle and laid with broken joints and thoroughly spiked together. The lower side of this circle was placed 18 in. above the lower edge of the vertical side plank and the whole solidly spiked together. The upper circle was made in a similar manner of two courses of plank, thus completing the form of a wooden tank or caisson without a bottom.

Within this caisson and resting on the lower shelf that had been provided for it, was built the stone wall which made the wheel pit proper. It was 26 ft. inside diameter and 25 ft. deep, with side walls 18 in. thick.

The next step was to provide a centrifugal pump with an engine to run it. The pump was fitted with an 8-in. flexible suction pipe and an 8-in. discharge and was of the kind fitted for pumping sand. The pump worked easily when the output was half or more sand and, indeed, would handle bowlders that were small enough to pass through the pipes.

The pump was mounted on the caisson so that it would follow down as the caisson settled. For the first few feet the pump simply lowered the water so that men shoveled the material into buckets and it was hoisted out in the old-fashioned way, but, as soon as there was sufficient depth of water, the shoveling ceased, and the pump was started at pumping out the sand from below the water. This worked well till we had lowered the caisson more than half way, when the lowering of the water from the inside caused such a rush of water from the outside that it brought in the sand with it, thus making a great amount of extra work. To counteract this, water was brought from the lake through the supply pipe, that had in the mean time been built,

and poured into the pit, so that no matter how much we pumped out, the water was higher inside than out, and there was no tendency of the sand to flow in.

In excavating, the suction pipe was moved around over the bottom of the pit under water, and as the material was removed the caisson settled down to its place. In building the walls of the caisson, arched openings had been built for the outflow of the water from the wheels when in operation.

The plan of the power house showed two pairs of horizontal turbine wheels set on steel frames across the top of the wheel pit, with draft tubes extending down nearly to the bottom of the pit, and discharging under water. The wheels were fed by a great pipe leading to them from the lake. This would mean a great amount of water falling from a height into the bottom of the pit, and this being of soft sand, would speedily wash out unless a solid bottom was put in.

This was done in the following manner: There being 15 ft. of water in the bottom of the pit, it was necessary to build the bottom at the top of the water and lower it down. A timber platform was made of three courses of 3-in. plank crossed and spiked together. This was circular in form and 1 ft. less in diameter than the pit, to be sure that it would pass any projecting rock in the walls. The platform was suspended at the surface of the water by three long rods extending up through the timbers that had been placed across the top of the walls. Each of the rods had been threaded for 15 ft., and had a large nut and washer at the lower end of the threaded portion, so that when the nuts were unscrewed the suspended bottom would sink into place.

A course of masonry 18 in. thick was laid in cement on the platform, and when dry was lowered by a man at each rod unscrewing the nuts in unison. The bottom having been made a foot less in diameter than the pit, there was an opening 6 in. wide entirely around the wall, and to make a complete and safe job this had to be filled with concrete, and being under 15 ft. of water, some unusual plan had to be devised.

It was found by experiment that a strong stream of water was flowing up from below through the opening between the bottom and side walls so that ordinary concrete would be washed out before it could set. To overcome this, there were made long sacks of cotton cloth about 8 in. in diameter, so that when filled and pressed down in the bottom of the opening they would completely fill it. These sacks were filled with dry concrete

and placed end to end in the opening and pressed down solidly with timbers. A second course of sacks was placed above the others so as to make the bottom surely tight. The remaining space was filled with loose concrete and as that had to be passed down through the water a way had to be found whereby it might be placed without having the particles of cement washed out of the sand.

This was accomplished by taking a seamless grain sack and splitting open the bottom; the bottom was then turned up some 8 in. and a small opening made through both parts; this was passed over a loop that had been fastened on the front of the sack and a wooden pin passed through. A small rope was attached to the pin with which to withdraw it when the sack was in place. Then when a small rope had been attached to each of the upper corners of the sack it was ready for service. To operate the device, the bottom is turned up and fastened on the loop with the pin, the sack is filled with dry concrete and lowered down through the water to the desired location. With a pull on the pin, the bottom opens and a careful lifting of the sack permits the concrete to fall out exactly in its final position without having been washed by falling loosely through the water. In this way the remaining space between the bottom and side wall was completely filled and piled up against the side to a slope of 45 degrees.

Having completed the inside, we turn to the outside. On the side of the pit towards the lake and for two thirds of the way to the front, the earth remains nearly to the top of the pit, but for the one third on the front, or outlet side, it is to be cut away to the level of the outlet windows, or nearly to the bottom of the pit. The material beneath the pit being nothing but sand and gravel there is extreme danger of its washing out when the great flow of water comes, and permitting the foundation walls to fall out. The back two thirds of the wall being covered with earth and away from any wash is safe; to make the front wall safe it was determined to build a concrete foundation below and in front of it. This was accomplished in the following manner: thirty pieces of 1½-in. pipe, 20 ft. long, were provided, and a strong stem force pump with a 50-ft. section of hose. The hose was coupled on to the pump and one of the pipes. The pipe was set up on end, in the sand, and a stream of water started through it. As the stream washed the sand away from the bottom, the pipe settled down rapidly till the whole pipe was down as far as desired. The hose was disconnected and attached

to another pipe and it was put down till all were in place. They were set $2\frac{1}{2}$ ft. apart, each way.

In making concrete it is only necessary to have sand, gravel, water and cement, and, as the first three were in place, it only remained to supply the cement. To accomplish this, an arrangement of pipes and valves was made, with one large pipe connected in, that would hold a bucketful or more of cement. This was connected on top of the first pipe and to the pump by the hose. The pump started a stream of water through the straight part of the pipe into the sand below, then a charge of cement was placed in the receptacle and the valves changed so that the stream would pass through the charge carrying it down and spreading it through the sand at the bottom of the pipe. As soon as a charge was spread, the flow of water was changed back to the straight pipe and another charge of cement placed in the receptacle. The whole pipe was lifted a few inches and the cement again distributed through the sand. This operation was repeated until the pipe was worked out, and continued with the other pipes till all had been worked, when the pipes were reset and the operation had covered the desired ground. In this way we put 55 barrels of Portland cement into the sand below and built a block of concrete 10 ft. wide, 8 ft. deep and 35 ft. long around the front of the wheel pit.

After completing this preliminary work, the excavation of the tailrace was comparatively easy. A small ditch was first excavated with teams to give the channel the proper course. After that, the bottom of the race was plowed, a strong stream of water turned in from the lake through the power house, and the loose material washed out; then the proceeding was repeated till the whole was complete and at vastly less expense than to have done it all with scrapers.

The power house was built with one end resting on the wheel pit and the other on piles that had been driven solidly into the soft material that has been described.

The pipe leading from the lake to the power house was built of wooden staves and steel bands and was 6 ft. in diameter. It rested in a trench that had been dug for it in the earth and was covered with 2 ft. of earth.

The plant developed 500 h. p., which has been utilized for city lighting, running two flour mills and several elevators. The plant has been running successfully for twelve years, but the plan for a great city fell by the wayside.

# SEWAGE DISPOSAL AT MANCHESTER AND BIRMINGHAM.

By Leonard Parker Kinnicutt, Member of the Boston Society of Civil Engineers.

[Read before the Society January 24, 1906.]

On my return from England last autumn, I was asked by the Executive Committee of the Sanitary Section of the society to give an account of the present status of the sewage purification plants at Manchester and at Birmingham, one being a typical example of the contact bed treatment, the other of the percolating filter process.

I consented only on one condition, — that what I had to say should not be in the form of a written paper, but in the form of an informal after-dinner talk, using for my material only the data I had obtained at the time of my visit, or in personal correspondence with Dr. Fowler and Mr. Watson. I am, therefore, not going to give any careful or complete description of either plant, which would be an old story, but only a talk that may answer certain questions that you would be likely to ask when visiting these two plants.

The population of the sewer district of Manchester is 600 000, and the dry-weather flow of sewage is calculated as being about 29 000 000 gal., with a storm water flow of about five times that amount.

The general plan of the sewage plant is as follows: Four settling tanks, capacity of each 1 630 000 gal.; 12 septic tanks, total capacity of 19 500 000 gal.; 92 first contact beds, each 0.5 acre superficial area, constructed of cement concrete and filled with furnace clinker rejected by a 1.5 in. mesh passed by a 0.25 in. mesh to a depth of 40 in. Besides these 92 first contact beds there is an area of 27 acres divided into 29 storm-water contact beds. In these beds the filling material, 2.5 ft. of unscreened furnace clinker, rests generally upon a heavy clay marl, though where needed a layer of cement concrete has been laid down. They are designed to operate at a rate of 3 000 000 gal. per acre per 24 hr. The original plan also included 52 half-acre second contact beds similar in construction to the first contact beds, except the filling material was to be somewhat finer; as yet, however, only one has been constructed.

At the present time the whole of the septic tank instalment

not being completed. part of the sewage, 40 per cent., is being treated chemically (lime and iron sulphate), and 60 per cent. by septic tanks. All of the sewage, both that chemically treated and that passed through septic tanks, is in dry weather carried to the contact beds; in wet weather the excess is treated on the storm beds.

The amount treated on the contact beds averages 600 000 gal. per acre per day. The effluent is, however, not perfectly satisfactory, often undergoing secondary putrefaction, and there is no question that to obtain uniformly satisfactory results this effluent must be treated on second contact beds.

At the present time 600 000 gal. of the effluent of the first contact beds is passed on to the one second contact bed (0.5 acre area) that has been built. The effluent from this second contact bed has so far been non-putrescible.

Allowing that a satisfactory effluent can be thus obtained, it requires for the satisfactory treatment of 600 000 gal. per day 1.5 acres, or one acre for 400 000 gal., and this is the figure that is now given by Mr. Fowler.

As regards the permanency of contact beds the original anticipations have not been fulfilled. The first contact beds at Manchester were put into commission in 1901. To-day these first beds are clogged to such a degree that it has been found advisable to remove the filling material, wash it, make good the waste and refill the beds. The greatest amount of clogging has taken place over the underdrains, and in some of the beds only the portion of the filling material over these drains is being removed, in other beds the whole material.

As to the cost of contact beds, Mr. Fowler kindly gave me the following figures: Original cost per acre, including excavation, underdraining, laying of the cement concrete and filling material in place, $13 000.

The filling material laid in place cost 87 cents per cu. yd. The cost of removal of this filling material this past year, washing it and replacing it was, when the whole bed was done, 31 cents per cu. yd. When the whole of the filling material of the bed was not taken out, but only those portions which had been badly broken down and clogged, it cost 41 cents per cu. yd. In neither case did this include the cost of new material to make up for that lost in the washing and sifting. The amount of material thus lost was large on account of the softness of the furnace clinkers originally used, and the replacement of lost material cost about 31 cents per cu. yd. This makes the cost of

reconstruction of the beds, with the washed and sifted material and new material, 71 per cent. of the original cost of filling material laid in place. The filling material, however, in these reconstructed beds is much better than the original material, as it is only the hardest and best portions of the original material that have been now placed in the beds, the softer portions being the part that was lost in the washing and sifting.

If we turn to Birmingham we find that the population of the drainage area is about 793 000, — 200 000 more than Manchester, — and that the total dry weather flow of sewage, 30 000-000 gal., is about the same as Manchester, the storm weather flow from 6 to 9 times the dry weather flow.

The Birmingham sewage is, however, a stronger sewage than Manchester sewage, albuminoid ammonia averaging 1.69 against 0.52 for Manchester; oxygen consumed 27.48 against 10.54 parts per hundred thousand parts. At both Manchester and Birmingham the preliminary treatment will, when the changes contemplated at Manchester are completed, be practically the same, — sedimentation and septic tanks. From that point the treatment is radically different, for, as we have seen, Manchester treatment is by contact beds, while Birmingham is by percolating filters. The general plan of the sewage plant at Birmingham is as follows:

There are 5 settling tanks and 20 uncovered septic tanks situated at Saltley. The settling tanks, each divided into three compartments, have a total capacity of 6 000 000 gal. The mean rate of flow of sewage through the tanks is 1.2 ft. per min., giving 4.36 hr. for sedimentation. The total capacity of the septic tanks, which average 8 ft. in depth, is 8 700 000 gal., giving 8 hr. for septic action. The effluent from these tanks, according to the present plan, is to flow in a closed conduit, 5 miles long, fall 2 ft. per mile, to Sutton Coldfield, where the percolating filters are situated.

At the present time only a portion is thus carried, the rest being flowed upon the land at various points. At the end of the conduit there is a large intake chamber from which the flow can be automatically regulated and delivered into settling tanks to remove a large part of the suspended matter which is contained in the effluent from the septic tanks as delivered at Sutton Coldfield.

These tanks, 5 in all, are of the Dortmund type. They are 44 ft. in diameter and 33 ft. 6 in. deep from coping level to bottom of the sump, the lower portion being in form of an

inverted cone having a batter of 1 to 1. The opening of the inlet pipes varies at the present time in the different tanks from 15 ft. 9 in. to 19 ft. 9 in. below the water level, the best depth having not as yet been determined. The combined capacity of these tanks is 810 400 gal., normal flow 42 170 gal. per hr., which gives an upward velocity through the cylindrical portion of the tank of 4.4 ft. per hr. and a sedimentation of 4 hr. These tanks remove, as shown by analyses, about 75 per cent. of the suspended matter contained in the septic tank effluent. From these settling tanks the clarified sewage is delivered on the percolating filters. Of these there are, at the present time, four experimental 0.25 acre circular beds, one 0.5 acre and five 1-acre rectangular beds. To these are to be added 10 more 1-acre rectangular beds, 3 of which are nearly completed, making it by far the largest plant of this description yet built. In addition, 30 acres of storm-water filters, to be built on the percolating system, have just been sanctioned by the Tame and Rea District Drainage Board.

The acre beds are all built on the same general plan, rectangular in shape, side walls of cobble, laid dry, bottom of concrete, fall about 9 in. across bed. The concrete is covered with an aërating floor of semicircular stoneware tile, laid loose jointed, on which the filling material, broken quartzite, fist size, is placed. The effluent from the silt tanks is discharged by means of fixed sprinklers, each bed being divided into 8 bays, each bay being independently supplied with clarified sewage by an 8-in. pipe.

The drainage from these beds is to be discharged into humus tanks of the Dortmund type so as to remove the so-called "humus" from the effluent before it is run upon the land.

As to the amount of sewage treated by the percolating beds, Mr. Watson has made careful measurements of the amount of sewage applied to each bed each week and in a letter dated January 1, 1906, he says: "I am now in a position to say definitely that the amount satisfactorily treated by our beds is about 750 000 gal. per acre per day, which is about 900 000 U. S. gal."

As to the cost of percolating beds, he says: "The cost of our bacteria beds, including all supply pipes, effluent channels, distributing pipes, filling material, etc., is between $29 000 and $31 500. The cost of the broken stone is $1.48 per cu. yd. delivered, to which must be added 12 cents per cu. yd. for conveying to and filling the bacteria beds, which gives a total of $1.60 per cu. yd."

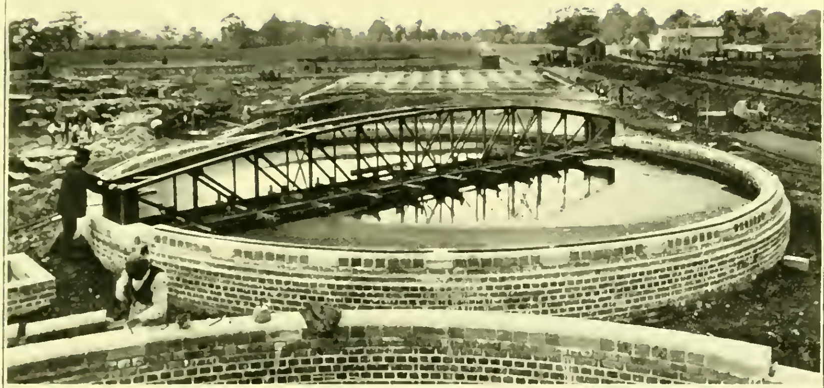


FIG. 1. DORTMUND TANK. USED AT BIRMINGHAM FOR REMOVING SUSPENDED MATTER FROM THE SEPTIC TANK EFFLUENT.

FIG. 2. CONSTRUCTION OF THE ONE-ACRE PERCOLATING FILTER AT BIRMINGHAM.

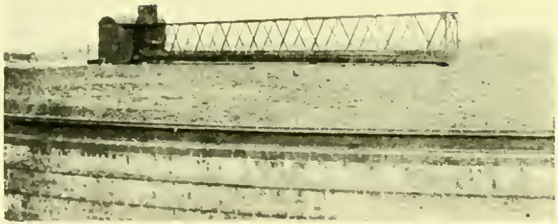


FIG. 7. ONE-QUARTER ACRE EXPERIMENTAL PERCOLATING BED, BIRMINGHAM, SCOTT-MONTCRIEFF DISTRIBUTER, KNOWN AS BED C.

FIG. 9. ONE-QUARTER ACRE EXPERIMENTAL PERCOLATING BED, BIRMINGHAM. WALLS OF DRY COBBLE.

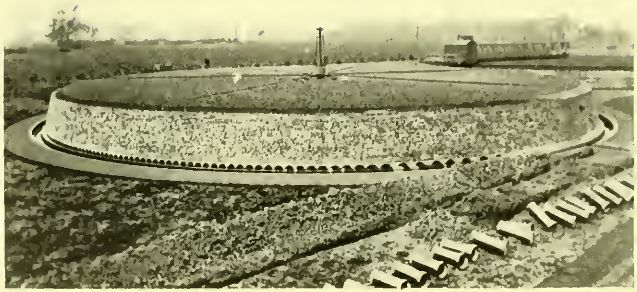
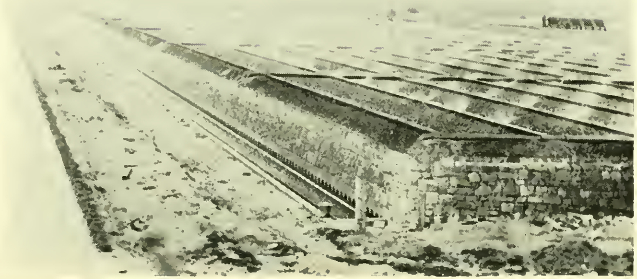


FIG. 4. ONE-QUARTER ACRE EXPERIMENTAL PERCOLATING BED AT BIRMINGHAM, ADAMS DISTRIBUTER, KNOWN AS BED B.

Fig. 8. Underdrains of the Acre Percolating Beds, Birmingham.

Fig. 5. Construction of the One-acre Percolating Beds at Birmingham.



Birmingham

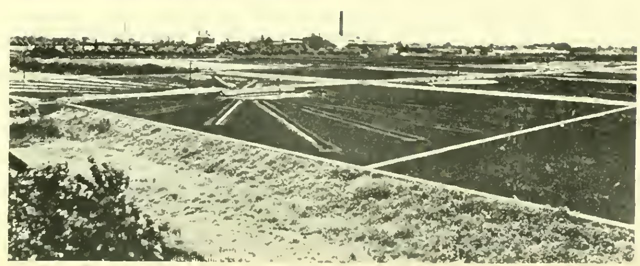


Fig. [illegible]. Contact Beds at Manchester.

As to the life of a percolating filter, Mr. Watson says: "Though believing that after use for a given period the filling material will have to be washed, and that such beds will not last forever, the period that a percolating bed will run before washing the material becomes necessary is still an unknown quantity. Personally, I believe that such a bed will run very much longer than a contact bed, allowing the same careful supervision in both cases."

As to the relative cost, in England, of contact beds and percolating filters, taking the data given by Dr. Fowler in one case, and that given by Mr. Watson in the other, the following comparison can be made: Original cost of well constructed contact beds, filling material, graded furnace clinker, $13 000 per acre.

Original cost of equally well constructed percolating filters, filling material, crushed stone, fist size, $30 000. Amount of sewage that can be satisfactorily treated by contact beds, 400 000 imperial or 478 000 U. S. gal. per acre per day.

Amount that can be treated by percolating filters, 750 000 imperial or 896 400 U. S. gal.

Cost, calculated per unit capable of treating one million U. S. gallons daily, contact beds, $27 196; percolating filters, $33 470.

Dr. Fowler's figures are, however, for contact beds filled with furnace clinker; Mr. Watson's for percolating beds filled with broken stone, and even if the life of the percolating filter is no longer than that of the contact bed, the material lost in washing and sifting when the beds are reconstructed must be much greater with furnace clinker than with broken stone.

The work accomplished by the various portions of the plant at Birmingham, as also has been the case at Manchester, has been studied in the most careful and thorough manner, and the tables of analyses printed below, those of Birmingham given to me by Mr. Watson and printed by his permission, those of Manchester derived from the annual report of the Rivers Department of the city of Manchester, are the results obtained by daily analyses of samples collected so as to give, as nearly as possible, the true composition of the sewage and of the effluents.

The effluent from the percolating filters, except that it contains suspended matter, is said to be perfectly satisfactory, and to be non-putrescible, as is indicated by the amount of nitrogen as nitrites and nitrates it contains.

It is interesting to note that as the result of the experiments at Columbus, percolating filters have been adopted for the treatment of the sewage of that city, and in many particu-

lars the proposed method is very similar to the plan as worked out by Mr. Watson. Capacity of plant at Columbus, 20 000 000 gal. per day. Six septic tanks, 4 primary and 2 secondary, total capacity 8 020 000 gal. Period of sedimentation, 8.5 hr. Period of sedimentation at Birmingham, about 12 hr.

At Columbus, 4 percolating beds, each 2.5 acres, total area 10 acres. Rate of flow on beds, 2 000 000 gal. per day. Rate of flow on percolating beds at Birmingham, 900 000 gal.

Taking the difference in strength between Birmingham and the average American sewage, the rate of flow on beds may be considered as practically the same.

The chief difference in the two plants is that at Columbus the tanks for collecting the suspended matter in the septic tank effluent are omitted, and that at Columbus the beds are to be treated with 4 000 000 gal. per acre per day for 2 weeks, and then allowed to remain at rest for 2 weeks.

Table of Analyses Showing Effect of Treatment of Manchester Sewage on Contact Beds, Rate 600 000 Gallons, and of Birmingham Sewage on Percolating Beds, Rate 900 000. Manchester Results for the Year Ending March 30, 1904; Birmingham, for the Year Ending January 1, 1905.

MANCHESTER.

Parts per 100 000.

| Source of Sample. | Free Ammonia. | Albuminoid Ammonia. | Nitrogen as Nitrites and Nitrates. | Oxygen Consumed. |
|---|---|---|---|---|
| Crude sewage .......... | 2.27 | 0.52 | .... | 10.54 |
| Septic tank effluent..... | 2.63 | 0.37 | .... | 9.35 |
| Contact bed effluent.... | 1.62 | 0.15 | 0.27 | 2.72 |

Average purification: On albuminoid ammonia basis, 71 per cent.
On oxygen consumed basis, 73 per cent.

BIRMINGHAM.

| Source of Sample. | Free Ammonia. | Albuminoid Ammonia. | Nitrogen as Nitrites and Nitrates. | Oxygen Consumed. |
|---|---|---|---|---|
| Crude sewage.......... | 4.28 | 1.69 | 1.05 | 27.48 |
| Septic tank effluent..... | 4.16 | 0.71 | 0.46 | 15.28 |
| Percolating bed effluent. | 3.39 | 0.27 | 2.20 | 2.57 |

Average purification: On albuminoid ammonia basis, 84 per cent.
On oxygen consumed basis, 90 per cent.

Running percolating beds in this manner is new and the result will be watched with interest.

In conclusion I do not for one moment wish it to be thought that I believe that either contact or percolating beds are advisable when the process of intermittent sand filtration can be used, for I think there is no question that where sand soil can be obtained or sand procurable at a permissible price, as is usually the case in New England, the method of intermittent filtration is by far the best of all biological methods.

TABLE OF ANALYSES SHOWING AVERAGE COMPOSITION OF SEWAGES AND EFFLUENTS FROM THE PURIFICATION WORKS OF THE BIRMINGHAM TAME AND REA DISTRICT DRAINAGE BOARD, DURING THE YEAR 1904.

PARTS PER 100 000.

| Source of Sample. | Suspended Solids. Total. | Suspended Solids. Volatile. | Free Ammonia. | Albuminoid Ammonia. | Chlorine. | Nitrogen as Nitrites and Nitrates. | Oxygen Consumed. |
|---|---|---|---|---|---|---|---|
| Crude sewage | 77.9 | 49.4 | 4.28 | 1.69 | 19.8 | 1.05 | 27.48 |
| Septic tank effluent | 35.0 | 23.2 | 4.16 | 0.71 | 19.6 | 0.46 | 15.58 |
| Silt tank effluent | 8.1 | 4.7 | 6.68 | 0.55 | 19.5 | ... | 12.00 |
| Percolating filter effluents | | | | | | | |
| Bed *A* | 4.6 | ... | 0.98 | 0.16 | 17.7 | 3.36 | 1.62 |
| Bed *B* | 1.1 | ... | 3.89 | 0.36 | 18.3 | 1.70 | 3.61 |
| Bed *C* | 5.6 | ... | 2.38 | 0.24 | 17.9 | 2.74 | 2.36 |
| Bed *D* (1) fine material | 1.6 | ... | 2.99 | 0.17 | 18.3 | 2.28 | 1.82 |
| Bed *D* (2) coarse material | 2.8 | ... | 5.58 | 0.37 | 19.5 | 2.04 | 2.03 |
| Bed *E* | 7.6 | ... | 2.33 | 0.22 | 18.5 | 2.27 | 2.57 |
| Bed 8 | 2.8 | ... | 5.57 | 0.37 | 19.5 | 0.85 | 3.96 |

*A*. One-quarter acre circular bed. Filling material, graded furnace slag, 6 in. at bottom of bed, .75 in. at top. Walls of bed of same material. Not underdrained. Mather & Platt distributer.

*B*. One-quarter acre circular bed. Filling material, graded gravel. Walls of cobble. Underdrains of semicircular tiles. Adams distributer.

*C*. One-quarter acre circular bed. Filling material, graded broken brick, 3 in. at bottom, 0.5 in. at top. Underdrained. Walls of brick. Scott-Montcrieff distributer.

*D*. One-quarter acre circular bed. Divided into two portions to test difference in action of coarse and fine material.

*D* (1). Broken quartzite, size 2.5 in. at bottom, 1.5 in. at top.

*D* (2). Broken quartzite, 0.75 in. diameter. Underdrains semicircular tiles. Whittaker distributer.

*E*. One-half acre rectangular bed, constructed below ground level Floor of concrete, fall 1 in 240, covered with semicircular stoneware tiles. The sides of the beds are excavated to the level of the floor and sloped back to give free circulation of air. The filling material is laid to

a depth of 6 ft. and consists of screened clinkers from the gas works, the lower 3 ft. being from 3 to 6 in. in diameter, the remainder passed through 1.5 in. screen. Sewage distributed by fixed sprinklers.

8. One acre rectangular bed. Walls of cobble, laid dry. Filling material, broken blue brick, 2.5 ft. of fist size, 1 ft. of 1.5 in., 1 ft. of 1 in., and 6 in. of 0.5 in. gage. Floor cement concrete, fall 9 in. across bed covered with aërating floor of semicircular tiles, laid loose jointed. Sewage distributed by fixed sprinklers.

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# THE OPERATION OF SEWERAGE WORKS.

## OPERATION OF THE SMALL SEWAGE FILTERS AT LAKE KUSHAQUA, N. Y.

BY ROBERT SPURR WESTON, MEMBER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

[Read before the Sanitary Section of the Society, March 7, 1906.]

AT the Stony Wold Sanatorium, Lake Kushaqua, N. Y., — an institution for the care of women suffering from tuberculosis,— the writer has installed a sewage disposal plant consisting of a septic tank, dosing chamber, sludge bed and two disposal beds. The septic tank has a capacity of 15 000 gal. The two sewage beds have an area of 0.22 acre, and each bed is used on alternate days.

The sewage is applied to the bed in doses by means of an automatic siphon. From three to five doses are applied to each bed daily, at the rate of about 135 000 gal. per acre per diem, or an average rate of 68 000 gal. per acre per diem. The area takes care of the sewage of about 125 people, and is designed to care for 200 people.

The cost of the plant was rather high, the work being performed under difficulties. The beds were excavated in hard-pan gravel, and most of the filling was hauled from a point 100 yards distant. The beds cost $8 450 per acre, and the septic tank cost $121 per thousand gallons' capacity.

No difficulty has been experienced in the operation of the beds, nor have they been a nuisance to the sanatorium, only 1 200 ft. distant. During the winter the beds have been covered

with several feet of snow, yet they have been operated without interruption.

The only difficulty experienced has been due to growths of algæ on the surface of the beds during the summer months. These growths have made more frequent scraping necessary. For example, during 1905, the beds were scraped three times during the open season. These algæ form a blanket over the bed and cause the filters to clog more rapidly than is usual. These algæ grow on the surface of the bed only. None are apparent where the effluent from the filters enters the lake. The cause for these algæ is not apparent. They are not the result of pools of water formed on the surface, but are rather the cause thereof.

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## THE SEWAGE FILTRATION PLANT AT THE CONTAGIOUS HOSPITAL, BROOKLINE, MASS.

By Alexis H. French, Member of the Boston Society of Civil Engineers.

[Read before the Sanitary Section of the Society, March 7, 1906.]

The hospital consists of five buildings, in addition to a laundry and a building of temporary character for smallpox patients. It is situated in the south part of the town, on a watershed tributary to the Neponset Valley sewer of the Metropolitan Sewer System. The trunk sewer of this system has been extended to the town line, but as it seemed improbable that there would be general call for its extension to the region in which the hospital is situated for many years, it was thought best to devise some other method of disposal.

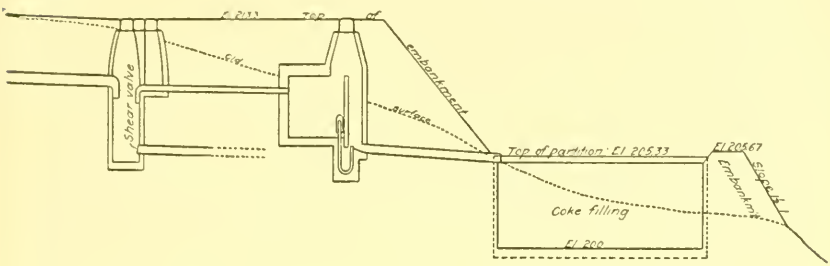
The land on which the hospital is located is rough and irregular and consists of a comparatively light depth of clayey soil overlying conglomerate ledges. The surface drainage is into swampy ground not owned by the town, some 40 ft. below the hospital buildings.

On the advice of Mr. Goodnough, engineer of the State Board of Health, it was concluded that the sewage would be sufficiently purified to permit the effluent being discharged into the low land above referred to, if the sewage were filtered through underdrained beds of coke breeze 5 ft. in thickness.

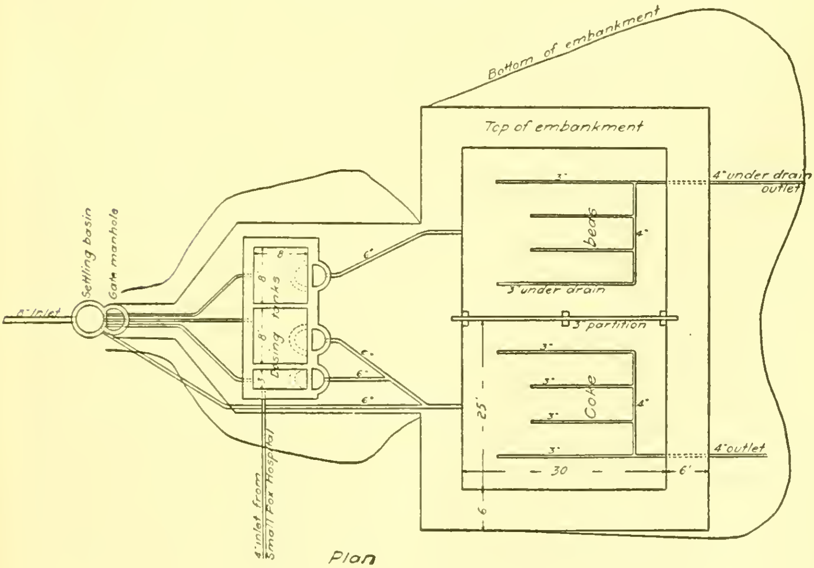
The hospital was designed for a maximum population of 70. On a basis of a water consumption of 100 gal. per capita per day, we have 7 000 gal. daily as the maximum

amount of sewage requiring disposal. Allowing for a maximum rate of filtration of 200 000 gal. per day per acre, we have 1 500 sq. ft. as the required area for the beds, which area was provided in the plan adopted.

On account of the varying number of patients, and in order




Longitudinal Section




Plan

that the dosing tanks should discharge once daily under all the varying conditions which may arise, three tanks were built, of the dimensions shown on the accompanying sketch.

The hospital has been occupied since October, 1902, and the method of disposal has been practically free from objection, although it should be said in passing that the hospital buildings are the only ones within 400 ft. of the beds. The coke used

ranges from $\frac{1}{4}$ in. to $\frac{3}{4}$ in. in diameter and appears to be well adapted for the purpose.

The Miller siphons failed to do the work for which they were installed, and one of them has been replaced by a Dececo. The others will shortly be replaced. With this single exception, the plant, as designed, has given satisfaction from the start.

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## SEWAGE DISPOSAL PLANT AT THE STATE COLONY FOR THE INSANE, GARDNER, MASS.

By J. J. Van Valkenburgh, Member of the Boston Society of Civil Engineers.

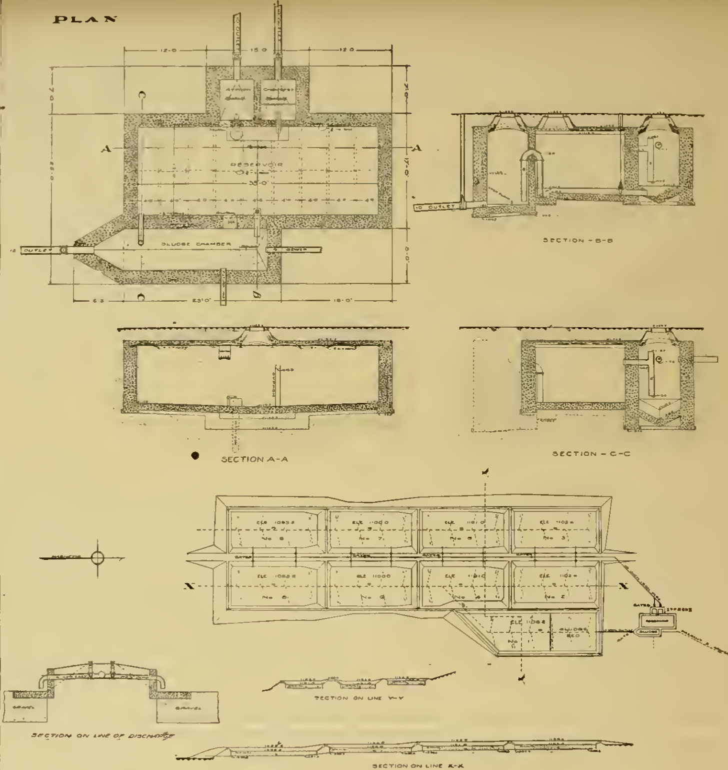
[Read before the Sanitary Section of the Society, March 7, 1906.]

The State Colony for the Insane is located in Gardner, near the Fitchburg Division of the Boston & Maine Railroad, about $2\frac{1}{4}$ miles south from South Ashburnham.

The area owned by the State comprises about 1 800 acres of rough land, on which it is proposed to employ the chronic insane patients taken from the state insane hospitals. At present the administration buildings only have been constructed and the number of inmates is about 275, but it is proposed eventually to provide for a much greater number. There is no sandy or gravelly soil within a long distance of the buildings, the soil being chiefly clay and hardpan, so that it is impossible to purify any considerable quantity of sewage upon the natural soil. It was decided, therefore, to construct artificial filter beds, and after obtaining estimates for filtering material of various kinds, it was determined to make the beds of sand brought from Fitchburg by the Boston & Maine Railroad.

The buildings are so located that it was possible to select a very desirable location for the filter beds, about 1 200 ft. from the buildings, in a secluded spot sheltered on three sides by a grove of trees. The sewage is conveyed to the filtration area through an 8-in. pipe which discharges into a small settling tank designed to remove only the heaviest portions of the sewage. From the settling tank the sewage passes into a dosing tank, from which it is discharged intermittently upon the filter beds.

The settling tank has a capacity of 7 472 gal. and the solid matter which accumulates in it is discharged upon one of the filter beds which is reserved for this purpose. There is a connection between the settling tank and the dosing tank which




PLAN OF

RESERVOIR AND FILTRATION AREAS

# STATE COLONY FOR THE INSANE.

## GARDNER MASS.

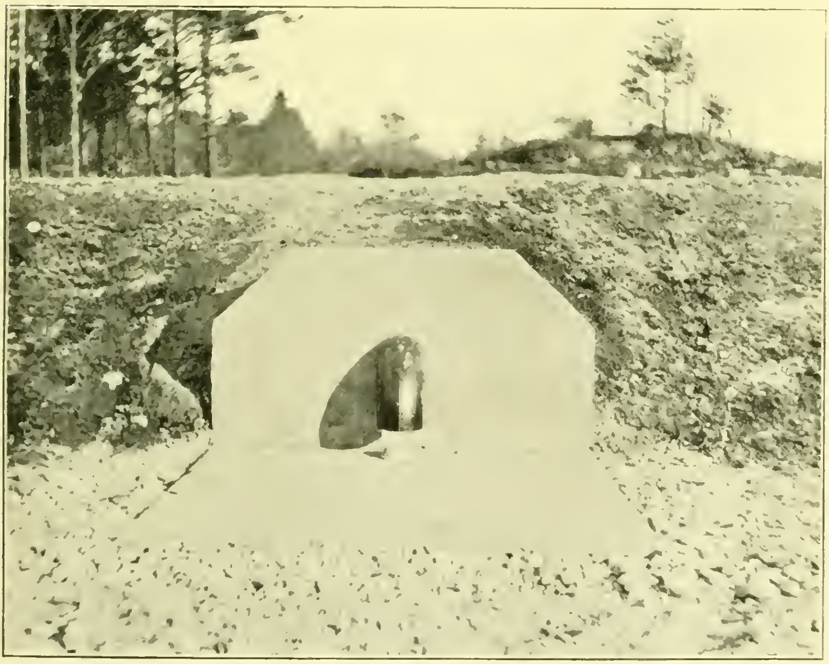
MAY 1904

J J VAN VALKENBURGH C.E.

Preparing System of Underdrainage.

Receiving Filtering Material.

Discharging upon Sludge Bed.



6-inch Outlet.

permits the rapid discharge of the contents of the latter through the former for the purpose of flushing out the heavy solid matter. The dosing tank has a capacity of 17 474 gal., sufficient to flood one of the filter beds to a depth of about 3 in. It is provided with a simple form of siphon, the construction of which is shown on the accompanying plan.

The filter beds which receive sewage from the dosing tank are 8 in number, each 100 ft. long and 50 ft. wide on the center lines of the embankments, making a total area of about one acre. The beds are on each side of a central embankment which is of sufficient width to form a roadway. The sewage is conveyed to the beds through a 10-in. cast-iron pipe laid in this central embankment with two 6-in. outlets on each bed. Each outlet is provided with an ordinary water gate. The sewage discharges through a quarter-bend so placed as to discharge the sewage downward upon a concrete apron. Immediately beneath the opening in the pipe is a conical-shaped mound of concrete so constructed as to cause the sewage to spread out equally in all directions.

The sludge bed, which is designed to receive the contents of the dosing tank, has an area of about 5 000 sq. ft. and is similar in construction to the other beds. A plank is placed across the center of the bed which intercepts the heaviest portions of the sludge, and the material which flows over the plank to the other half of the bed consequently contains much less solid matter, so that it is necessary, ordinarily, to clean only one half of the sludge bed.

The soil where the beds are located consists of clay with many bowlders, and the area in the beginning was very rough and covered with trees, stumps and bushes. The area was first cleared of stones and roots and leveled to receive the sand, the embankments being formed with the material removed in the process of leveling. The embankments were held in place by planks which were removed as soon as there was sufficient sand in the beds to hold them.

The underdrains were laid before the filtering material was placed. The main underdrains are 6 in. in diameter, with a fall of 6 in. in each bed. The laterals are 3 in. in diameter. The depth of the underdrains is from 4½ ft. to 5 ft. beneath the surface of the filtering material. The joints of the pipe were wrapped with muslin and 6 in. of crushed stone were deposited over the drains. This was followed by 3 in. of clean screenings. The crushed stone around the drains was held in position by

planks which were removed when covered by the filtering material. (See photographs.)

The central embankment is 8 ft. wide on top and all other embankments are 2 ft. in width. The tops and slopes of all embankments were covered with 6 in. of loam and were seeded.

The sand used for the filtering material was furnished by the Boston & Maine Railroad Company from a pit about $1\frac{1}{2}$ miles east of the Fitchburg Railroad depot. The railroad company built a spur track from the main line to the beds, the track ending on the central embankment between the two rows of beds, — a distance of about 2 400 ft. from the main line of the railroad.

The price paid to the railroad company for the sand was 70 cents per cu. yd. This price included the cost of building and removing the spur track; changing the location of the track from time to time to accommodate the necessities of the work, and the material was furnished when and where wanted. The round trip from the pit to the filtration area was about 28 miles, and when required the company delivered 3 train loads per day with 7 cars on the train, each car holding 20 cu. yds. The contractor received 40 cts. per cu. yd. for excavation, which included the building of the embankments, and 19 cts. per cu. yd. for unloading the sand from the cars and putting the same in place; 20 cts. per ft. was paid for furnishing and laying the 6-in. underdrain and 14 cts. per ft. for the 3-in. lateral drains. The State furnished the crushed stone, but the contractor at his own expense hauled it 1 200 ft. The total cost of the filter beds complete was $9 966.82 or $13 280. per acre of filtering surface or about $8 500 per acre of filter beds measured on the center lines of the embankments. The cost of the settling and dosing tanks was $2 400, making the total cost of the plant $12 366.82.

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## THE SEWERAGE SYSTEM OF THE HYANNIS STATE NORMAL SCHOOL.

By George H. Wetherbee, Jr., Member of the Boston Society of Civil Engineers.

[Read before the Sanitary Section of the Society, March 7, 1906.]

In the year 1897, a state normal school was opened at Hyannis, a town very prettily located on Cape Cod, 72 miles

south of Boston, and at that time a water plant and a sewerage system were established.

The sewerage system was to take care of the sewage from the school building and the dormitory, the latter to accommodate about 60 students. The system then put in consisted of a 4-in. pipe taking the sewage from the two buildings southerly across South Street to a cesspool situated on the slope of the hill, with an overflow 5 ft. from the bottom, extending to two roughly prepared filter beds built one above the other, differing in elevation by 1.4 ft. By means of a wooden spout, sewage could be conducted to either bed.

In the spring of 1901, I had an invitation from Mr. Baldwin, the principal of the school, to look the ground over with the idea of rearranging the system. I found the sewage flowing slowly from the cesspool on to the filter beds, emitting an offensive odor. Complaints had been made by dwellers in the immediate neighborhood because of these odors and the unsightliness of the beds. After making some surveys and a careful study of the surroundings, I decided to locate a new filtration area about 200 ft. easterly from the old beds, where sand of a very good quality was found, and to distribute the sewage upon this area through pipe laid 2 ft. beneath the surface. Owing to the fact that the Summer School followed closely the ending of the regular school year, the old system could not be disturbed, so I planned to connect the new pipe line with the old sewer at a manhole just north of South Street, following nearly the line of the old sewer to a reservoir. This reservoir has a capacity of about 630 gal., or about $\frac{1}{6}$ of the daily flow, and when filled discharges automatically through a 5-in. Miller siphon into an 8.-in. pipe through which it flows to the filtration area.

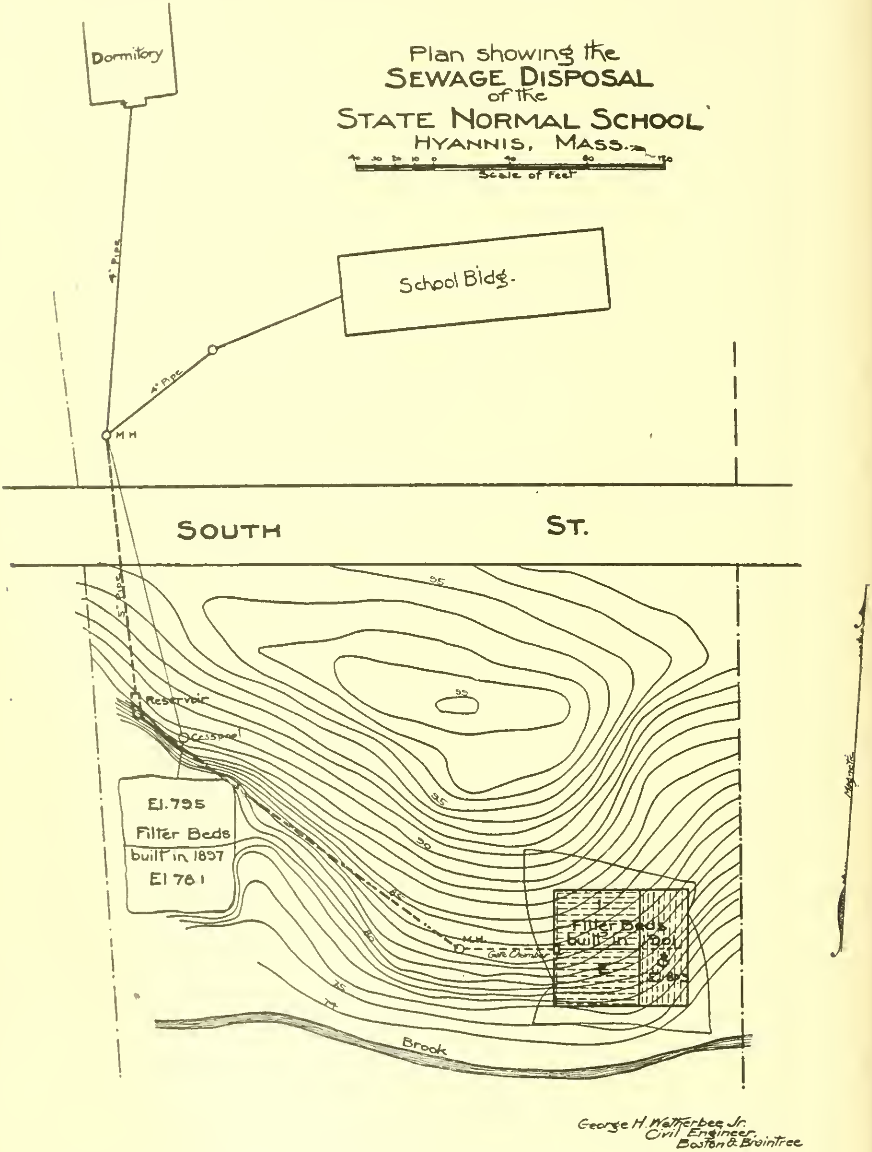
This area is divided into three beds. Beds 1 and 2 contain 1 350 sq. ft. each, while bed 3 contains 1 500 sq. ft. By means of a gate chamber the sewage is directed to the different beds through 8-in.pipes, from which at 3-ft. intervals, and at right angles, 6-in. agricultural tile extends into the beds.

These beds were first used in the autumn of 1901; in August, 1904, the pipes were relaid, and an extension of the beds is contemplated the coming year.

In the original plan a wire screen was built in the reservoir to intercept papers or other solids, and was worked mechanically through an iron cover in the top of the reservoir; this was attended to for a while but finally given up.

When the future extensions are made I hope that a septic

tank may be installed, or, better still, a filter bed, built at a lower level than, and adjacent to, the present beds, upon which




the sludge that now collects in the pipes can be frequently flushed.

No analysis of the sewage or effluent has been made.

The total cost of the system as built in 1901 was $900.

## THE DISPOSAL OF SEWAGE UPON THE WATERSHEDS OF THE METROPOLITAN WATER SUPPLY.

By William W. Locke, Member of the Boston Society of Civil Engineers.

[Read before the Sanitary Section of the Society, March 7, 1906.]

The present water supply of the Metropolitan District consists of surface waters drawn from Lake Cochituate; from six artificial reservoirs and Whitehall Pond upon the watershed of the Sudbury River; and from the Wachusett Reservoir constructed upon the south branch of the Nashua River above Clinton.

The area of the Cochituate watershed is 19.84 sq. miles, lying in the towns of Wayland, Natick, Sherborn, Framingham and Ashland; that of the Sudbury watershed is 75.2 sq. miles, lying in Framingham, Southborough, Marlborough, Ashland, Hopkinton and Westborough, with small areas in Northborough, Upton and Holliston; that of the Wachusett watershed is about 118 sq. miles, lying in the towns of Clinton, Boylston, Paxton, Holden, Rutland, Princeton, Sterling, Leominster and West Boylston, with small areas also in Worcester, Hubbardston and Westminster.

The sanitary census recently completed shows the total population upon the Cochituate watershed to be 15 508, or 781.7 per sq. mile; on the Sudbury 21 131, or 281.0 per sq. mile; and on the Wachusett 5 772, or 49.0 per sq. mile. It becomes evident at once from a glance at these figures that the densest populations are upon the Cochituate and Sudbury watersheds. Fortunately the towns of largest population are all located near the divide lines so that it was not difficult to dispose of their sewage outside the watersheds. Sewerage systems have been installed in Natick, Framingham, Marlborough and Westborough; in the first two towns the sewage is pumped and in the last two it runs by gravity about two miles to intermittent sand filtration beds. The waters of Hardiman Brook, which drains an area of 2 sq. miles in the most thickly settled parts of Marlborough, with a population upon it of 10 074, and the waters of Pegan, Bacon and Macewen brooks, which drain an area of 1.09 sq. miles in Natick, with a population of 3 743, are also run upon sand filtration beds constructed and operated by the Metropolitan Water and Sewerage Board and filtered before they enter the reservoirs.

Up to the present time 1 427 premises out of a total of 2 873 upon the Cochituate watershed, with a population of 8 987, have been connected with the public sewers, leaving 6 521 people, or 328.7 per sq. mile, whose house drainage is still disposed of upon the watershed. Upon the Sudbury watershed 1 898 premises out of a total of 4 607, with a population of 10 556, have also been connected, which leaves 10 575 people, or 140.6 per sq. mile, whose house drainage is disposed of upon the watershed. In other words, 58 per cent. of the population upon the Cochituate watershed and 50 per cent. upon the Sudbury need not be considered further in the discussion of the sewerage problem. There are also about 2 850 people upon the Cochituate watershed and 3 130 upon the Sudbury whose drainage will be eliminated when all possible extensions of the present systems have been completed. Connections at the average rate of 153 premises per year have been made during the past 7 years. Still there will be a population of approximately 11 000 upon the Sudbury and Cochituate watersheds and 5 772 upon the Wachusett whose drainage must be treated by works in the vicinity of the dwellings. It is this drainage which we shall now consider.

Geologically the Cochituate watershed is mostly a great sand plain with only one large swampy area near Waushakum Pond. A large portion of the Sudbury watershed has an impervious subsoil with a mixture on top of clay, sand, gravel and stones and an outcropping of rocks in many places; but a fair filtering material can usually be found near at hand, if not actually upon the spot where needed. The Wachusett watershed is like the Sudbury in many respects except in the westerly and southwesterly portions, where sand and gravel are scarce.

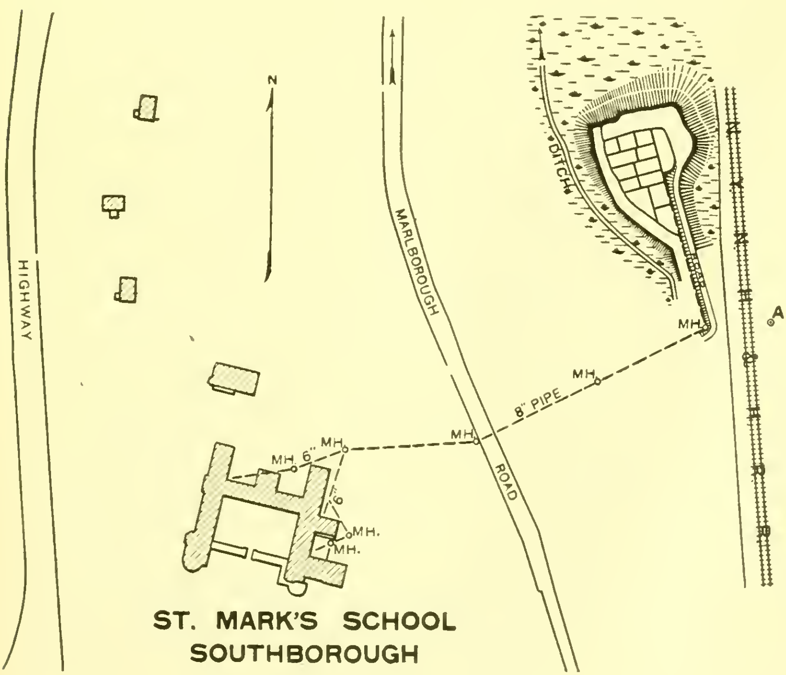
From this brief statement of the character of the soil, it will be seen that the easiest solution of the house-drainage problem is generally the construction of a cesspool, and for the protection of the Metropolitan water supply it is usually effective if the cesspools are properly located and built of adequate capacity. Unless direct supervision of their construction is taken by the inspector, however, owners are very likely to build them too small, with the result that they soon overflow. There are 983 cesspools upon the Cochituate watershed, 1 511 upon the Sudbury and 532 upon the Wachusett.

If only the health of the people upon the watersheds were to be considered, cesspools should not be built where a better

method of disposal can be found, as the turning of large quantities of putrescible organic matter into the ground, there to lie and slowly decay or to contaminate the soil or wells in the vicinity of dwellings, undoubtedly affects the health of the inhabitants. The construction of intermittent filter-beds of sand is much more hygienic and scientific, as they allow the sunlight and air and the nitrifying organisms to destroy the organic matter without polluting the soil. The only valid objections that I have ever heard raised against filter-beds are that they take up considerable space, are unsightly and require regular, intelligent attention. The last one is the most important objection, as, of course, people not scientifically trained cannot comprehend how the successful operation of the system must depend upon such little things as the regular opening and closing of gates and the raking off of a little sludge.

### St. Mark's School, Southborough.

A small area was first used for filtering purposes in 1891. This was added to from time to time, and in 1901, at my suggestion, the whole area was divided into 13 small beds as shown




ST. MARK'S SCHOOL
SOUTHBOROUGH

on the cut. The total filtering area is about 14 000 sq. ft. The population is 216, of whom 135 are students. The average quantity of water used per day for 10 months is 30 000 gals., with a maximum of 40 000. During July and August the institution is closed and no sewage runs upon the beds. This makes the rate of flow about 100 000 gals. per acre per day while the beds are in commission. They are located upon a gravel knoll and were built by cutting off the top. The actual cost of construction cannot be easily determined, as the excavated material was used to build the embankment for the sewer and for various purposes about the grounds. This excavating has been continued up to the present time, resulting in the irregular area shown beyond the beds which will be utilized for additional beds during the coming summer, thus increasing the total area nearly 50 per cent.

The manager of the institution attends to the gates himself, changing the flow twice daily as he goes back and forth from the school to his home. The labor required outside of this daily supervision is 2 days per week at $1.65 per day for 5 months, or $72.60 per year.

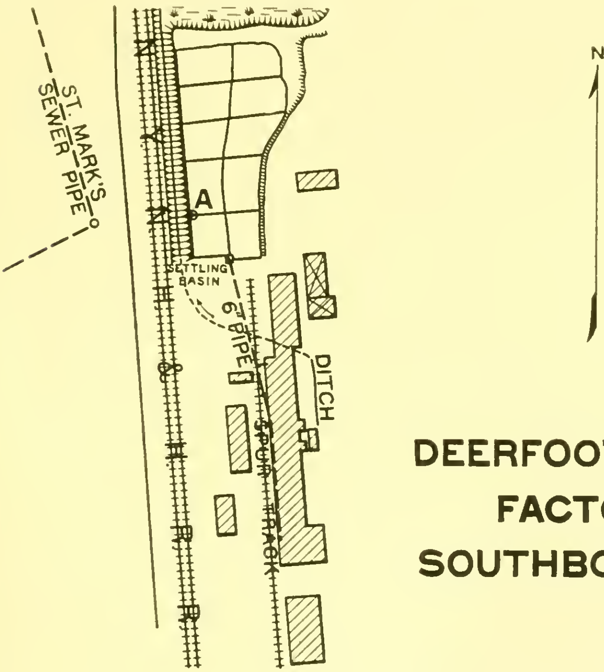
The filtering material is rather poor, being a mixture of fine and coarse sand and large stones which run in streaks. The beds are 12 ft. above the small brook and swamp which lie at the foot of the slope and 32 ft. above high-water mark in the Sudbury Reservoir, and are not underdrained.

## Deerfoot Farm Beds.

One bed was built in 1897 and contained an area of 10 273 sq. ft. This was operated continuously until 1901, when, at my suggestion, it was divided into 4 beds and 6 more were added by taking gravel from the east bank and filling in the swampy area below. This increased the filtering area to 26 400 sq. ft. These beds are not underdrained and lie about 6 ft. below the St. Mark's beds and 6 ft. above the swamp.

The average number of employees during pig-killing time, which lasts for 200 days from October to April, is 60, and during the remainder of the year, when only the milk and butter departments are in operation, an average of 30 is employed. Five thousand pigs are slaughtered annually, about one third of the blood and the washings from the slaughtering, packing and sausage departments going upon the beds with the washings from the milk and butter departments, where 1 200 cans of milk are handled and 400 lb. of butter are made daily. An average

of only 25 000 gal., or 41 000 gal. per acre per day, is run upon the beds, but the character of the sewage is such that it is fortunate the quantities are no larger. Although the material is much more uniform and better adapted for filtering purposes than that on the St. Mark's beds, there is generally an unpleasant odor arising from it which the management has not been able to suppress entirely.



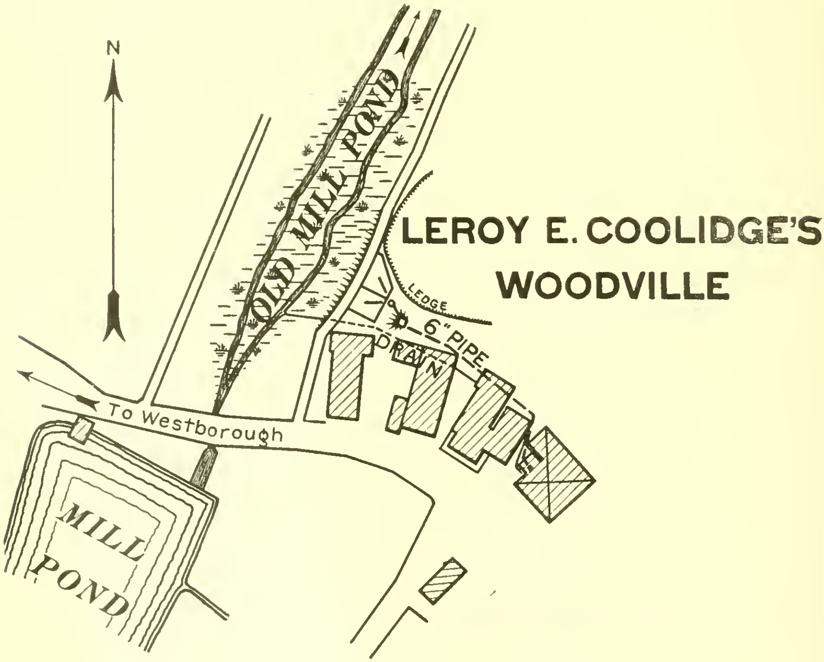

**DEERFOOT FARM FACTORY SOUTHBOROUGH**

It is not possible to give even an approximate estimate of the cost of building these beds, as the work was done by the men employed in the pork department when there was nothing else for them to do. The cost of maintenance is about $300 per year.

### Leroy Coolidge's.

This plant consists of a livery stable, hotel, electric light station and carriage manufactory. Formerly the drainage from the stable and hotel ran directly by a drain into Whitehall Brook. In 1903 the present system, designed by Mr. Leonard Metcalf, was built. It consists of a 6-in. pipe line, a dosing tank 10 ft. by 12 ft. by 4 ft. deep and two artificial sand filter-beds, each with an approximate area of 1 250 sq. ft. It was difficult,

because of ledge, to find a suitable area for the location of the beds. Finally a public way running between the buildings was taken and a new way built by filling out into the old mill pond with the excavated material from the site of the beds. Four-inch open-jointed tiles were then laid, upon which 3 in. of screened gravel 1 in. to 2 in. in diameter were spread; then 3 in. of gravel $\frac{3}{8}$ in. to 1 in.; then 3 in. more of coarse sand from $\frac{1}{8}$ in. to $\frac{3}{8}$ in., and upon the whole 3 ft. 3 in. of coarse sand of very good quality. This sand was found in a pit about 1 mile away and was not



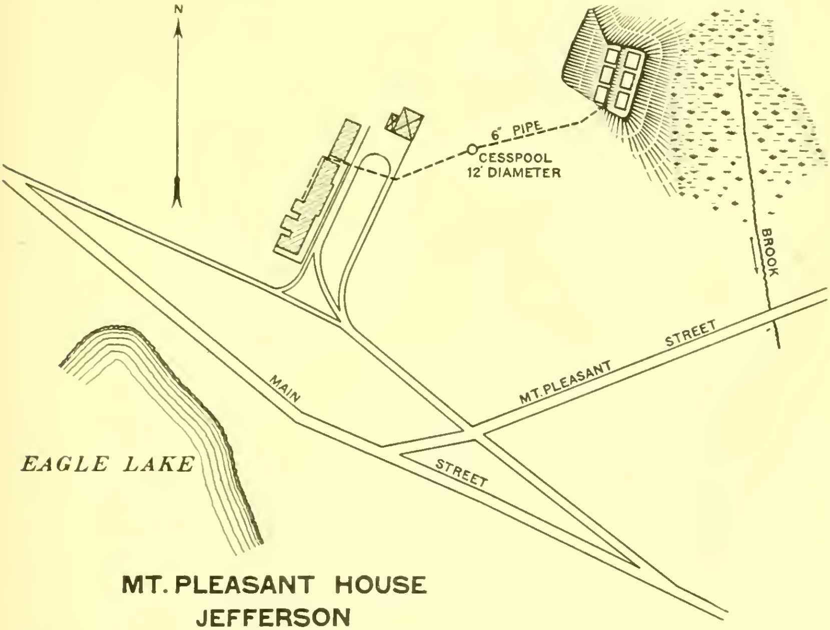

screened. The cost of the system was relatively large because of the difficulties encountered.

The average quantity of sewage from the hotel is only 700 gal. per day and this is all that goes upon the beds except for 2 or 3 months of the year when there is usually a large addition from the cellar of the livery stable. The beds are cared for by the engineer of the electric light plant. He empties the dosing tank twice a week and rakes off the sludge whenever he thinks it is necessary. At first the beds worked too freely, as inside of 15 min. after the dose was applied the sewage had disappeared from the surface and was running from the under-

drains. It came out clear and colorless but with a bad odor. As the beds gradually silted up, better results were obtained, and inside of a year the cold effluent had lost its odor.

### Mt. Pleasant House, Jefferson.

This is a family hotel, having about 150 guests in summer and 20 in winter. Originally the sewage ran to a large cesspool near the main street with an overflow pipe into Eagle Lake. In 1903 6 filter beds, each about 20 ft. by 30 ft., were built by the Metropolitan Water and Sewerage Board at a total cost of

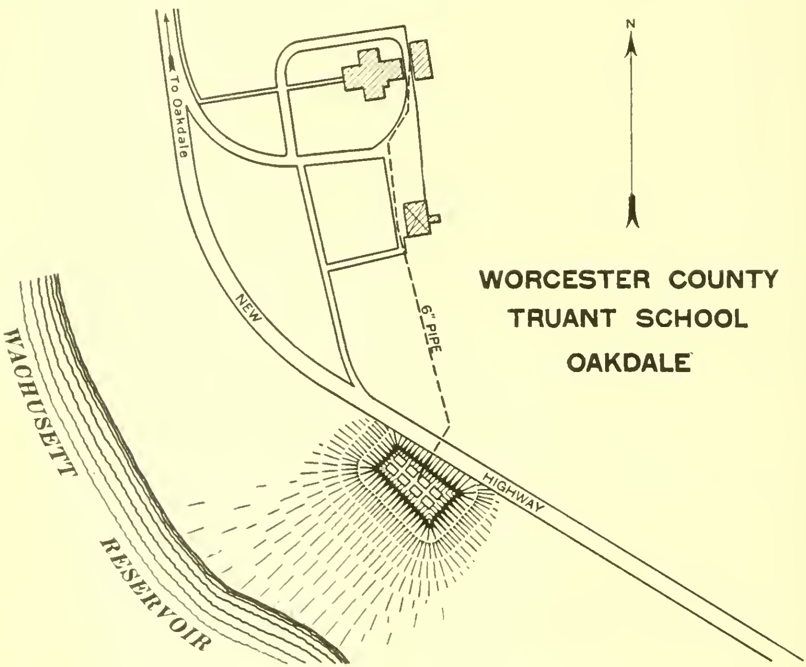



**MT. PLEASANT HOUSE JEFFERSON**

$485, not including the cost of the sewer pipe. The beds are located on the hillside, about 500 ft. east of the hotel and 40 ft. below it, at the only point where filtering material could be found. Satisfactory results are obtained even though the material is not especially good for filtering purposes, being a fine sand mixed with more or less clay, and the management of the beds is in the hands of the hotel people themselves. In 1904 a large cesspool was built on the sewer line to receive the winter's flow, as the sewer froze solid at the lower end during the coldest weather. The maximum quantity of water used during the summer is 5 000 gal. per day, with a daily average for the year of 1 500 gal.

### Worcester County Truant School.

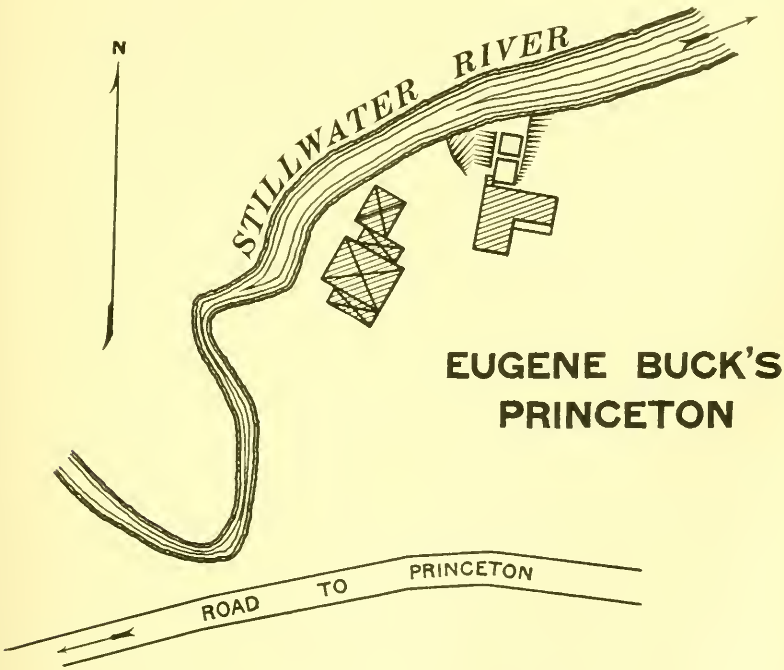
The sewage from the school ran originally to a small cesspool in the driveway, with an overflow pipe down the hill to the South Branch of the Nashua River. In 1903 the Metropolitan Water and Sewerage Board constructed 8 filter beds each 15 ft. by 20 ft. in a natural pot hole about 300 ft. from high-water mark of the Wachusett Reservoir and 50 ft. above it. The material is especially good for filtering purposes and we are operating these beds ourselves, as they were built on land owned




by the Board. They are about 35 ft. below the school and 750 ft. from it. The total cost of construction, including the sewer, was $525. The number of people in the school is 50 and the daily average sewage flow is about 1 200 gal., with a maximum of 1 800. The flow is changed from one bed to another every 10 days, at which time the depth of sewage upon the bed is 12 in. During the past year the beds have been cleaned and the sludge removed three times, at a total labor cost of $7.85. I have never noticed anything stronger than a slight musty odor arising from the beds even in May before the sludge from the whole winter's flow had been removed.

EUGENE BUCK'S.

The cut is intended to show what may be done at a farm-house containing only six people. A cesspool was out of the question, as the material was ledge overlain with bowlders and clay. Originally the sink drainage ran upon the surface at the rear of the house and soon found its way into the river. The clay and bowlders were removed down to solid ledge, which had a dip toward the river of about 10 per cent. Coarse sand and gravel were hauled about 0.75 mile and the two beds, each




about 10 ft. by 12 ft., were built. The depth of sand close to the house is 3 ft. and at the lower edge of the second bed about 5.5 ft. A small trough conveys the sewage to the further bed. Mr. Buck attends to these beds himself, changing the flow once a week in warm weather, first raking and removing the sludge from the bed which has been resting for a week. These beds were built by the Metropolitan Water and Sewerage Board at a cost of $81.50.

The method of operation of all the systems in winter is to place stones about 6 in. in diameter at frequent intervals on the beds,

then confine the sewage flow to one bed until a covering of ice is formed which will act as a protection to the bed, keeping the sewage warm and allowing it to filter in the coldest weather. This plan worked well a year ago and two years ago, when there were many days of very cold weather.

No chemical or bacterial examinations were made of the effluents from any of these systems, as Leroy Coolidge's is the only one in which the beds are underdrained.

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## TEN YEARS' EXPERIENCE WITH BROAD IRRIGATION AT VASSAR COLLEGE.

By Ellen H. Richards and Charles W. Moulton.

[Read before the Sanitary Section of the Boston Society of Civil Engineers, March 7, 1906.]

An editorial in the *Engineering Record* of January 27, 1906, on recent views of the sewage problem, states that "The old idea that sewage farming is the best method of disposal was exploded long ago, and the sewage farms still in service are not kept in operation because they afford the most economical treatment, as a rule."

Soon after its promulgation, the farm disposal idea suffered a defeat from which it has not recovered. It came before the conditions of success were understood. Clayey soils, easily water logged, are, as we now know, unfavorable to the bacterial activity required. In the far-away decades of the sixties and seventies, even down to the eighties, there was no recognition of the fact that nearly all the value of one batch of sewage applied to land *may* be lost as gaseous nitrogen by the application of the next batch, and that a considerable portion always is lost. Hence the disappointment in the meagerness of results.

There are cases when the question "Will it pay?" has to be answered, "Not in money, but in sanitary service to mankind."

Such a case arose ten years ago when Vassar College, situated about two miles from the east bank of the Hudson River, and south of the city of Poughkeepsie, was enjoined from turning the sewage of 1 000 persons into Kaspar Kill Creek, a small tributary to the river. It was proposed to build a sewer some six miles in length to the Hudson at an unknown cost (estimated at $50 000). But, in view of the possibility that in 20 or 30 years the enlightened state authorities would pro-

Looking Southeast from Outlet of Irrigation Pipe, showing Furrows for Distribution. Line of Trees in Front of Barn Marks Gully bounding Field.

Diagonal View across Filter Bed toward Corner where Sewage Empties. The Sewage sinks in without covering the whole Bed. Undisturbed Snow in Foreground. Dike in Distance run-

hibit the turning of untreated sewage into rivers, the trustees were willing to have an experiment tried involving much less expense.

An ideal field with most suitable material offered itself for irrigation and was laid out under the direction of the lamented Albert F. Noyes and of Allen Hazen.

No one of the advisers quite dared to risk broad irrigation by itself, and so the two filter beds were constructed. The pipe line is 3 000 ft. long to the filter beds and extends 500 or 600 ft. farther to the irrigation outlets. The beds cover 1 acre; the filling is 0.3 to 0.4 mm. effective size. The ground water level being 15 ft. below, no underdraining is necessary. The line carries easily 10 000 or more gallons per hour. The original cost, including the engineering reports on abandoned projects, was $7 500.00.

The description of the installation will be found in the *Engineering Record* for June 27, 1896.

The filter beds have not been refilled in the ten years. The surface is plowed and harrowed over every four or six months. If the grade from the pipe is kept up (not allowed to sink so that water stands) and paper stirred up occasionally to prevent clogging, the sewage received from 8 A.M. to 2 P.M. (the usual hours of pumping) disappears before the next morning. The two *beds* are used alternately whenever the *field* is out of commission more than four weeks at a time. This use occurs between planting and harvesting, and whenever an intense cold is in danger of freezing the pipes leading to the field. These are laid only 4 to 5 ft. below the surface and on a raised dike. They have not broken and have not needed repair in the ten years.

When college opens in September, the silo corn is gathered, furrows are plowed out radially on each side of the dike, extending 40 to 50 rods, so that there is a grade of about 1 in. in 30 ft. At the end of 6 hours' pumping the water has reached a distance of 300 ft. in these furrows, the soil being porous enough to absorb about all the liquid within 6 hrs. of stopping the pumps.

Since fresh sewage gives no offense, it is only when the grade has been allowed to wash out and a puddle to form that cause for complaint arises.

The crop raised is silo corn, which grows to a height of 16 ft. The yield of the land has steadily increased and is now 50 tons ensilage per acre — double what it was at first. For 2 years there has been no good corn in the region except on this

farm. About 10 acres have been irrigated with something like 100 000 gallons per day. Approximately 20 acres are available, at little expense, if branch pipes are laid.

To rake the field and beds requires two men and a team, 8 days for each bed, twice a year.

The inspector should visit the outlet every second day to see if anything is going wrong.

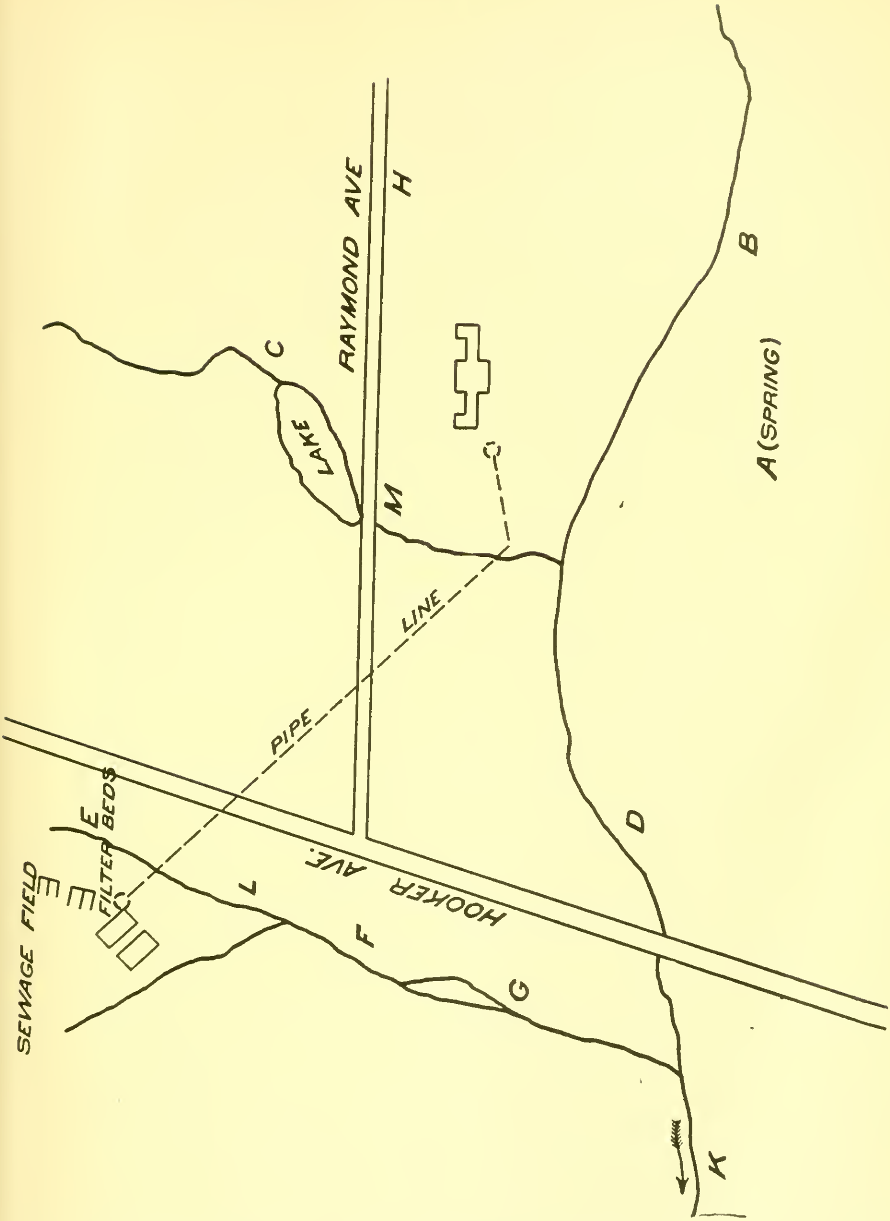
The great element of success is the character of the soil — a sandy loam. The lime, iron and humus content make a favorable combination for utilizing the values of the sewage. Sand is a good filter medium, but lime and humus will purify more efficiently.

Analysis of the Soil.

| Sieve Mesh. | Per Cent. passing through. | Per Cent. Humic Acid. | Color Am. Standard. | Parts per Million. | |
|---|---|---|---|---|---|
| | | | | Loss on Ignition. | Oxygen Consumed. |
| 30 | 10.0 | 1.51 | 18.5 | 55 | 69.7 |
| 40 | 12.1 | 1.03 | 18.5 | 60 | 70.9 |
| 60 | 28.8 | 1.60 | 13.9 | 53 | — |
| 80 | 12.6 | 1.78 | 12.5 | — | 59.8 |
| 100 | 17.7 | — | 11.7 | 48 | — |
| 120 | 8.5 | — | 13.5 | — | — |
| 170 | 16.6 | 2.66 | 25.0 | 84 | 116.6 |

Doubtless much of the nitrogen is lost by denitrification, but no great increase in that of the deeper ground waters has taken place, as shown in the analyses. Samples have been taken at least twice a year by Professor Moulton and a close watch kept of the general conditions. The table gives selected results covering the ten years, together with those of surrounding localities for comparison.

This is a valuable record of the possibility of sewage utilization without offense, and of the right principle in taking care of the wastes of an establishment by itself, instead of fouling a stream to become a menace to the health of others, and an expense to helpless dwellers farther down. It is thus in the line of modern economic and sociological investigation — a line which must be followed up if the land is to remain safely habitable.




A is a spring on the slope of Sunset Hill, unpolluted water. B is from the creek as it enters the college grounds on the North. D is the same creek just before it leaves the grounds on the South below the gas works. It was, at this point, very offensive at the beginning of the investigation. C is a small stream coming into the grounds from the West and feeding the boating lake. H is the well from which the college supply has been pumped. E is taken above the sewage field and beds from a small stream parallel to C, flowing through farming country. L is the stream just below the beds. F is the stream after receiving a tributary, draining a large stock barn and the sewage field. K is the creek after the junction of this drainage stream.

ANALYSES.

PARTS PER MILLION.

| Point of Collection. | Date. | Total Solids. | Alb. Amm. | Free Amm. | Nitrites. | Nitrates. | Hardness. | Chlorine. |
|---|---|---|---|---|---|---|---|---|
| A Spring | May 28, 1896 | 73.0 | .014 | .000 | .000 | .050 | 44.0 | 1.1 |
| B | September 30, 1895 | 190.0 | .232 | .014 | .007 | .200 | 94.3 | 9.8 |
| | May 5, 1896 | 135.0 | .058 | .006 | .000 | .070 | 81.0 | 3.0 |
| | October 13, 1905 | 160.0 | .264 | .024 | .001 | .300 | 73.0 | 6.6 |
| C | September 30, 1895 | 214.0 | .090 | .000 | .007 | .800 | 120.6 | 7.1 |
| | May 5, 1896 | 224.5 | .126 | .034 | .014 | 1.560 | 152.0 | 8.1 |
| | March 5, 1902 | 186.0 | .124 | .092 | .014 | 1.900 | 103.7 | 7.7 |
| | October 13, 1905 | 247.0 | .140 | .010 | .006 | .750 | 153.0 | 9.2 |
| D | September 30, 1898 | 193.0 | .162 | .120 | .025 | .750 | 103.0 | 7.2 |
| H Water Supply of Vassar College | October 10, 1895 | 157.0 | .012 | .002 | .000 | 2.600 | 90.0 | 3.6 |
| | May 5, 1896 | 136.0 | .006 | .000 | .003 | 1.050 | 87.0 | 3.6 |
| | November 12, 1897 | 153.0 | .006 | .000 | .000 | 1.203 | 84.0 | 3.6 |
| | September 30, 1898 | 133.0 | .000 | .000 | .000 | 1.100 | 74.0 | 4.0 |
| | November 6, 1900 | 140.0 | .001 | .000 | .000 | 1.600 | 88.0 | 5.1 |
| | December 10, 1902 | 161.0 | .006 | .000 | .000 | 1.500 | 104.0 | 6.1 |
| | October 29, 1903 | — | .000 | .000 | .000 | 2.000 | 88.0 | 4.4 |
| | March 16, 1905 | 170.0 | .008 | .004 | .001 | 1.000 | 105.0 | 5.6 |
| | October 13, 1905 | 173.0 | .004 | .000 | .000 | 1.250 | 107.5 | 5.24 |

PARTS PER MILLION.

| Point of Collection. | Date. | Am. Standard Color. | Total Solids. | Loss on Ignition. | Total Alb. Amm. | In Sol. Alb. Amm. | Free Amm. | Nitrites. | Nitrates. | Oxygen Consumed. | Hardness. | Chlorine. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | September 9, 1895 | 0.03 | 99.0 | — | .020 | .010 | .000 | .002 | 1.220 | 1.131 | 56. | 3.4 |
| | September 30, 1895 | 0.10 | 110.0 | 19.0 | .038 | .020 | .000 | .003 | 1.000 | 1.248 | 59. | 3.4 |
| | October 14, 1895 | 0.45 | 239.5 | 75.5 | .396 | .300 | .452 | .043 | 1.600 | 7.566 | 122. | 10.0 |
| | October 28, 1895 | 1.30 | 187.5 | 42.5 | .288 | .204 | .032 | .009 | 0.150 | 14.820 | 115. | 7.6 |
| | April 16, 1896 | 0.23 | 150.0 | 33.5 | .150 | .130 | .060 | .005 | 0.330 | 3.388 | 109. | 3.7 |
| | May 28, 1896 | 0.30 | 158.0 | 42.5 | .172 | .148 | .016 | .012 | 0.350 | 2.120 | 90. | 3.4 |
| | November 19, 1896 | 0.12 | 180.0 | 30.0 | .146 | .118 | .022 | .011 | 0.300 | 2.847 | 139. | 4.2 |
| E | November 12, 1897 | 0.17 | 209.7 | 35.0 | .100 | .088 | .056 | .007 | 0.700 | — | 94. | 5.6 |
| | September 30, 1898 | 0.18 | 196.0 | 34.0 | .066 | — | .022 | .012 | 0.580 | — | 126. | 4.5 |
| | March 5, 1902 | — | 175.0 | 35.0 | .116 | — | .090 | .015 | 1.900 | — | 104.5 | 3.7 |
| | October 29, 1903 | — | 213.0 | — | .048 | — | .030 | .030 | 1.900 | — | 150.0 | 4.0 |
| | December 3, 1904 | — | — | — | .090 | — | .040 | .005 | 0.500 | — | — | 3.4 |
| | October 13, 1905 | — | 190. | 38. | .262 | — | .084 | .011 | 0.350 | — | 128.0 | 6.0 |
| | December 26, 1905 | 0.03 | 207. | 29. | .042 | — | .038 | .001 | 1.700 | — | 170. | 3.6 |
| | October 28, 1895 | 0.70 | 145.5 | 30.5 | .148 | .112 | .004 | .003 | 0.030 | 10.920 | 94. | 5.0 |
| | November 11, 1895 | 0.20 | 135.0 | 22.5 | .080 | .074 | .008 | .001 | 0.280 | 2.379 | 86. | 4.4 |
| | April 16, 1896 | 0.25 | 144.5 | 23.5 | .140 | .114 | .024 | .004 | 0.330 | 3.080 | 109. | 3.2 |
| | May 28, 1896 | 0.30 | 131.5 | 21.0 | .142 | .096 | .042 | .006 | 0.400 | 2.574 | 103. | 4.2 |
| | September 16, 1896 | 0.22 | 156.0 | 31.0 | .116 | .090 | .090 | .020 | 0.400 | 2.106 | 97. | 5.8 |
| | November 19, 1896 | 0.12 | 175.0 | 43.0 | .094 | .078 | .018 | .002 | 0.600 | 2.301 | 116. | 8.5 |
| | November 12, 1897 | 0.10 | 205.0 | 45.0 | .094 | .064 | .026 | .005 | 0.850 | — | 101. | 10.9 |
| L | September 30, 1898 | 0.18 | 217.0 | 64.0 | .046 | — | .012 | .008 | 1.900 | — | 127. | 13.6 |
| | November 6, 1900 | 0.20 | 310.0 | 72.0 | .046 | — | .004 | .010 | 6.500 | — | 161.4 | 25.1 |
| | March 5, 1902 | — | 198.0 | 33.0 | .112 | — | .114 | .016 | 2.250 | — | 121.1 | 9.96 |
| | October 29, 1903 | 0.17 | 203.0 | — | .032 | — | .014 | .020 | 2.500 | — | 139.1 | 6.8 |
| | December 3, 1904 | — | — | — | .122 | — | .038 | .006 | 2.500 | — | — | 11.2 |
| | October 13, 1905 | — | 206.0 | 49.0 | .180 | — | .044 | .009 | 1.000 | — | 133.0 | 9.0 |
| | December 26, 1905 | 0.10 | 219.0 | 37.0 | .046 | — | .052 | .002 | 2.300 | — | 175.4 | 6.7 |

PARTS PER MILLION.

| Point of Collection. | Date.* | Solids. | Alb. Amm. | Free Amm. | Nitrites. | Nitrates. | Chlorine. |
|---|---|---|---|---|---|---|---|
| | September 30, 1895 | 142.0 | .122 | .094 | .010 | .300 | 5.0 |
| | October 14, 1895 | 198.0 | .276 | .192 | .033 | 1.000 | 8.0 |
| | December 17, 1895 | 123.0 | .082 | .090 | .006 | .530 | 2.4 |
| | April 16, 1896 | 150.0 | .122 | .014 | .004 | .500 | 4.0 |
| | May 28, 1896 | 141.5 | .112 | .048 | .011 | .400 | 6.8 |
| | September 16, 1896 | 153.0 | .940 | .148 | .030 | .400 | 6.2 |
| F | November 21, 1896 | 177.0 | .094 | .030 | .002 | .800 | 10.6 |
| | April 14, 1897 | — | .072 | .014 | .006 | .400 | 6.0 |
| | November 12, 1897 | 210.0 | .102 | .042 | .005 | .850 | 11.1 |
| | September 30, 1898 | 235.0 | .182 | .018 | .010 | 2.000 | 15.6 |
| | December 3, 1904 | — | .064 | .060 | .007 | 2.650 | 13.8 |
| | October 13, 1905 | 210.0 | .216 | .034 | .008 | 1.000 | 8.2 |
| | December 26, 1905 | 231.0 | .042 | .092 | .003 | 8.000 | 11.0 |
| | October 14, 1895 | 204.0 | .496 | 1.008 | .050 | .300 | 10.4 |
| | December 17, 1895 | 215.5 | .228 | .696 | .020 | .800 | 6.9 |
| | April 16, 1896 | 143.5 | .202 | .088 | .007 | 7.200 | 4.5 |
| | May 28, 1896 | 167.5 | .244 | .018 | .040 | .400 | 5.8 |
| | September 16, 1896 | 192.0 | .246 | .072 | .080 | .400 | 7.5 |
| | November 21, 1896 | 185.0 | .268 | .264 | .014 | .500 | 7.2 |
| K | April 14, 1897 | — | .244 | .078 | .012 | 1.000 | 5.1 |
| | November 12, 1897 | 87.0 | .312 | .144 | .007 | .550 | 7.0 |
| | September 30, 1898 | 190.0 | .148 | .116 | .040 | .700 | 6.2 |
| | December 3, 1904 | — | .128 | .256 | .007 | 1.400 | 6.4 |
| | October 13, 1905 | 176.0 | .204 | .164 | .009 | .400 | 11.10 |
| | December 26, 1905 | 168.0 | .120 | .370 | .006 | 1.800 | 6.4 |

## SOME FOUNDATIONS FOR BUILDINGS IN CLEVELAND.

By Gen. J. A. Smith, Honorary Member of the Civil Engineers' Club of Cleveland.

[Presented to the Club Feb. 13, 1906, with discussion Feb. 13 and 27.]

I do not want to take exceptions to the announcement as given, but it may perhaps be as well in the start to know that I am not going to have any paper. I have simply a few points that have been jotted down as memoranda that I may bring them in in their proper sequence, and they will not be read. I hope to make the points sufficiently clear as we proceed.

Cleveland is a city that is fortunate in having somewhat upon which to rest. That is true not only of its people, of its homes, but of its sand. This discussion will be limited to the small section of Cleveland on this side of the river as far as Erie Street and including that which we ordinarily term the business part of the city. There is perhaps no better way in which we can tell what to do in the future than by what has been successfully done in the past; and while we do not always want to go along through the world looking backward in order that we may see what is behind, the wise man will occasionally glance back to get the information which he needs for his forward road. Cleveland, within a comparatively few years, has grown to be a city in which large buildings have arisen. I propose to take you along with me to a few of them.

Among the earliest, not the very earliest, was the building known as the Arcade, reaching through from Euclid Avenue to Superior Street. Its foundations are upon the sand, with a difference of level between the foundations at the two streets of about 11 ft. 3 in., and that entire difference of level, if I remember correctly, is within a distance of about 70 ft. The foundations of that building were put in upon a very fine sand and in the water, protected, as I understand, while being constructed, by caissons of boiler plate, which, however, have been omitted in many buildings similarly constructed since. The weights upon those foundations (in the water) vary between the limits of 3.25 and 4.25 tons per superficial foot. The observations of the architects and others have not detected any material settlement, in fact, practically none at all, and *none which is unequal* throughout the building.

Within little more than a year a new power plant has been erected for that building, and I am informed that portions of that plant, including its engines, rest upon foundations deep in the water, so as to look as though they were afloat, and they carry 3.5 tons per superficial foot, *absolutely without settlement to detect.*

If we pass along further east to the Hollenden Hotel, upon the street between the rear of the Hollenden and the rear of the Garfield Building, we find that a recent addition has been made to that hotel. I have had occasion from time to time to observe the excavation in the sand and the putting in of ordinary foundations upon ordinary footings. This part [illustrating] is intended to represent the rear of that addition that has been built ten stories high, and that against which it was built is eight stories high. What is singular and noticeable about this is that when the top of the wall of the old part was reached — in which I myself had rooms some fifteen years ago, so that I know it has been in position at least so long, and has doubtless reached all the settlement it ever will, — this second wall was carried over on the top of the wall of the old part, whereas up to that height the two walls are separately built. I have been watching for a catastrophe. I have been waiting to see whether cracks would appear from the top of the old wall to the corner of these windows [illustrating] and to see whether they would extend anywhere through these walls, as they surely would if the new part had settled. It may be that my eyesight is not good, but from the narrow width of the street and on pretty nearly the same level, I have failed to discover any indications of a break because of the settlement of the lower part away from that which would be held above by the old wall.

If we come along to the Citizens Building at our next door, we find a structure 183 ft. high. Its foundations are on sand about 2 ft. above the water. The plan was to distribute the weight as nearly uniformly as possible, and the weights there have been small compared to some of these other buildings. They are calculated at the rate of 2 tons per superficial foot. I have had an office in that building something like two years and a half and have rarely gone through it without glancing at the walls to see if a crack could be found. I have not been greeted thus far with any such sight. The architects state that there has been no settlement in the building, but where the sand had been disturbed, broken loose under the sidewalk, portions of the sidewalk had noticeably settled.

We are in a building approximately of the same height, and just across the alley is the Rose Building. They stand as mute testimonials to the solidity of their foundations, and if we walk back down the avenue we pass some more.

First, the Guardian Trust, recently built, and then we come to the Williamson Building. That building was erected at a time when the pumps had to be kept going to clear the water so that the men could work; a permit was obtained from the Director of Public Works to enable them to work on Sunday to prevent their excavations being filled with water. Its foundations rest upon the fine sand in water.

It may be noted that on the site where the present Post-office Building is being erected the old postoffice stood for many years, and adjacent to it, the Case Building. I do not know what may have happened to them, but if anything very serious happened on account of instability it has not generally gotten out, so as to be known.

Near that place is the Society for Savings, one of the heaviest buildings in the city. Its foundations, to be sure, are comparatively shallow, compared to some of the later buildings, but it stands there and is likely to remain until some of us shall have passed away.

Perhaps the most remarkable foundations in recent constructions are those of the new Rockefeller Building. A few days ago I took pains to put in an entire half day in examining that building and went with the architect from the top to the bottom of it, making a complete examination. I have made a sketch here, which shows the principle to illustrate, but, of course, does not show in exact scale.

The sidewalk grade has been taken at 82.24 above the mean lake level, and the footings of the front part are at an elevation of 66.24 or 16 ft. below that datum; 5 ft. 10 in. above these footings is the floor of the front part in which are the safety vaults. In the rear of that part and down an additional distance of more than 15 ft., a retaining wall has been put in here [illustrating]. In rear of this wall is the "Machinery Hall," of which the floor is more than 25 ft. below datum of sidewalk.

The room for boilers and storage of coal is still lower, being about 27 ft. below the datum, and the footings of walls are 5 ft. 10 in. below the respective floors. These lower footings all rest upon the fine sand in the water and the lowest are but two feet above the underlying stratum improperly designated as "clay."

From the footings on the Superior Street front to the lowest footings under other parts of the building, the difference of level is about 17 ft., and the building stands in the water like a vessel in the lake, with a draught of at least 10 ft.

Between the footings of the walls and piers a layer of concrete 8 in. thick was placed on the sand; this concrete was covered with a water-proofing and upon that was placed another layer of concrete 6 in. thick. Between this concrete and the floors of machinery hall and boiler room, the space is filled with sand. Notwithstanding the depth of water around the lower rooms, a 4-in. well or boring, recently made through the floor of Machinery Hall to a depth of 40 ft. below the clay surface, was without any inflow of water. The architects called it "a dry hole." This seems to indicate that the material immediately overlying the clay is neither a "quicksand" nor other porous material. In fact, this material when moist may be squeezed into a lump in the hand, and the lump when dried becomes somewhat hardened, though easily crumbled.

Inquiry regarding the settling of the building elicited information that the settlement had been about 2 in., and had been so nearly uniform that no difference had been detected. As there is a large difference in the thickness of the sand underlying different parts of the foundation, the conclusion seems inevitable that the uniform load of 3 tons per superficial foot on the footings had caused no perceptible compression of the sand, and that the settlement must therefore have been due to displacement or compression of the underlying material.

Of course, such a conclusion assumes the accuracy of the statement of fact, which has been repeated as understood and noted when given by the architect of the building.

All of you know of many more buildings than I have mentioned, as being founded on the compact sandy material underlying the surface of the larger part of this city, and many of them contain busy machinery which keeps up a constant throbbing and jarring which tax the foundations far beyond what any steady pressure could do.

Some of the experience which has been gained by observing the results of such practical application of sound judgment in the past, has been codified and arranged in this book which we all know as the New Building Code. From this I propose to read a single paragraph relating to foundations:

"SECT. 2. Foundation Soil [page 47]:

"Foundation walls are to be laid on solid natural earth,

or a level surface of rock, or concrete. Where solid earth or rock is not obtainable the foundation walls are to be supported on caissons filled with concrete or on piles," etc. In other words, this Building Code indicates that where we have a solid soil upon which to build, that should be utilized without going to the needless expense of placing it upon foundations which are only justified when we have nothing better upon which to build.

Some three years ago, 26 borings were made on the lake front on the site where it was proposed to erect a new Court House. Those borings were all made down and into the clay to a depth of from 50 to more than 60 ft. below the surface of the ground, and as a general rule, 25 ft. or more into the underlying clay. The material over that clay was reported to be generally of a sand, becoming finer and cleaner with additional depth, to the top of the clay, and later experiments have found that the water stood over that clay at a level of about 49 ft. and 8 in. above the lake.

Let me invite your attention to the fact that those borings were made from the top of the surface to the bottom of the clay, removing the auger at short intervals of 2 or 3 ft. to obtain the samples of material which were preserved. Those holes were made without casings and each time that the auger was removed and reintroduced into the hole it went down again to the bottom of the previous boring. In that same line a similar result has recently been obtained by the Cleveland Engineering Company down here in the little alley we know better as Hickox Street. There, in the several borings that were made, the engineers tell me that each time the auger was replaced it went entirely to the bottom of the hole from which it had been raised, and although seven or more feet of the fine sand over clay is in the water, even then the material did not fall into the hole.

There has been a popular idea that that sand overlying the clay was a quicksand. It is quite possible that may be true in some little pockets, but it certainly *is not true in the place in Hickox Alley*, or in several other places in which I have seen the boring records; nor is it true down near the foot of Ontario Street between Summit and Lake streets. There is no true quicksand there. It is simply a very fine gray sand, doubtless mixed with some other very fine material.

As an addition to the 26 borings some tests were made last spring. First, a well 6 ft. in diameter was sunk in a casing of boiler plate iron. The bottom of that casing now stands near the bottom of the fine sand which apparently carries the weight

of the casing which would slide down of itself if not supported, and the pressure from the outside has not raised the surface inside the cylinder at all, as recent measurements have shown.

The well was first sunk to the water level, which was 49 ft. 8 in. above the lake level. From the bottom of the well a long pile was driven to a penetration of 37 ft. and 4 in. Material around the pile was then removed to a depth of 5 ft. below the surface of the clay, still leaving a depth of 27 ft. 8 in. of penetration. The diameter of the pile at the point was 8 in. and at the top of the part in the clay it was about 1 ft.

With a view to testing the bearing capacity of the pile, it was loaded with pig iron to the amount of perhaps 200 or 300 lb. more than 14 tons. Under the weight the pile settled 3 in. in two weeks, according to information furnished by the county surveyor's office, and the observations, which were not very regularly taken, indicated an accelerated motion so that in the last two days of the two weeks the settlement was 1.2 in. The result, therefore, only showed that such a pile penetrating more than 27 ft. in the substratum of clay, with its point more than 57 ft. below the street, and more than 60 ft. below surface of the ground, could not be depended upon to hold nearly as great a weight as 14 tons.

From the bottom of the same well a hole was then bored to a depth of 70 ft. below street grade, which brought the bottom of boring to the lake level. The substratum called clay was found to be substantially uniform and homogeneous throughout. From other sources we well know that this substratum is practically the same throughout the very large area underlying nearly all and perhaps all of the city of Cleveland.

At the Kirtland Street pumping station which is on a lower level than this plateau, there is no overlying stratum of sand, and as the clay stratum can carry but small amounts without settlement, piles were driven to sustain the exterior walls, engines, and chimney. Under the walls, chimney, and engines large piles were driven to a penetration of 35 ft. from the bottom of an excavation such that the column of earth above the top of pile caps on the outside is 27 ft. The piles were not less than 8 in. in diameter at the points and not less than 14 in. in diameter at the top. Of course, some of the piles were larger than the dimensions given.

Upon the piles driven to support outer walls a load of 15 tons each was placed. Under the chimney and engines the load was 12 tons per pile. As an experiment that construction has

not determined the load which such piles will safely carry in that material, because they have all settled. Let it be remarked that the material in which the piles were driven is in all essential respects the same as that which underlies the sand at the Court House site, it being a continuation of the same original formation.

The engineer in charge of this work states that accurate measurements have not been made of the settlement under the walls, but it is quite unequal and is estimated at from 1 to 2 in. Under the chimney the settlement has also been unequal, and has ranged from about five eighths of an inch to double that amount.

Of course, we understand that the amount of settlement is not large, but neither were the weights, though the amounts were too large and too unequal to be hazarded under any very important building, as the cracks in the pumping station amply demonstrate.

No such amounts of settlement as these can be found in the heaviest buildings of Cleveland, where they have foundations spread upon the hard sand which has been incrusted in the ages which have gone.

Now we come to a little practical application of some of these points. If a pile on the site of the Court House, driven 27 ft. and 8 in. in the clay, with its point more than 60 ft. below the surface of the ground, lamentably fails to hold a little more than 14 tons, how big must a pile be to hold anything? This is in all seriousness, because we have a similar problem before us. With this experiment, and the fact that large piles at the pumping station driven 35 ft. in the clay with their points more than 60 ft. below the top of the ground failed to sustain 12 tons each without settlement, by what process of logic can we expect that a metal pile 14 in. in diameter and driven but 20 ft. will hold 25 tons without settlement?

But this is exactly what the specifications require the shorter piles to do. In the specifications for building the Court House the method described to determine the length that piles must be driven to hold the loads that are to be placed on them is simply this: The contractor is to drive 12 piles each 20 ft. long, in groups of four in different parts of the building site. Each of the groups is to be loaded with a weight of 100 tons, and the specifications require that this load must produce no settlement during one week.

In some places we use wooden piles where they will be constantly saturated so as to be beyond a question of decay, but if

they are to be used under a building where decay is possible, it becomes necessary to introduce a material which is not subject to that element; therefore the introduction of what are commonly known as concrete piles. These are ordinarily a hollow form, usually of some wrought metal, filled with concrete. Should the metal decay, the concrete would still stand and hold its load.

Regarding the size and shape of the piles in this case, the specifications permit either a cylindrical form with a diameter of 14 in., or a tapering form with ends 10 and 18 in. in diameter respectively. When an option is given between two methods one may be sure of the adoption of that which costs the least, which would apparently be the one with the cylindrical form.

Again referring to the requirement for determining the lengths of piles to sustain the loads which they must carry, suppose that the piles should refuse to obey instructions, and should settle under their load of 25 tons each; by what reliable formula shall we deduce the lengths to carry other loads?

I have tried without success to repress the question, " What are we going to do should the piles settle contrary to instructions? " And how can we reasonably expect any other result when our experimental pile driven to a much greater depth failed to sustain a load which was less than three fifths as much? How are we to justify ourselves in assuming that these piles, but 20 ft. long, whether driven the whole length or not, will hold 25 tons each without settlement, when large piles driven 35 ft. in the same general formation failed to hold without settlement a load less than one half as great?

I have recently looked over some tables giving certain coefficients of friction. Unfortunately, no coefficients are given for friction of metal in the earth, or for wood in the earth. But in general the coefficients for metals are less than for wood, and you will find that the average coefficient of friction of metals upon each other or upon wood is considerably less than the corresponding coefficients for wood upon wood. This is not without exception, but is true in general. It seems logical to conclude that the surface friction of a metal pile driven in the earth would be less than that of the wooden pile which has a less uniform surface.

Another principle comes in here. Water under pressure due to its own weight or other conditions will follow the division between two uniform surfaces to a wonderful distance. I have known serious injury to a dam of earth because of the passage

of wagons over it during construction, so that there was a hard and practically uniform surface between the earth compressed by the wagon wheel and the superincumbent material.

The material underlying the sand at the Court House site is by no means impermeable to water, and it is ordinarily covered with water-bearing strata. Under such conditions it is a well ascertained fact that there is a greater liability to settle with the lapse of time because of the admission of water between the pile and the surrounding earth. It seems probable that this effect would be greater in the case of a pile with metal surface than with a surface of wood which would be less smooth and uniform.

The pile maintains its load through two agencies. Primarily we have the force which is required to displace the material in which the pile is driven, and to that is added the friction upon its surface. The greater the depth to which the pile is driven, the greater the force required to displace the material from under its point, and to force it laterally by the tapering form. While the lower end of a pile is generally smaller than the upper end, the greater resistance of material around the lower part is such that for the purpose of discussion we may assume that of two piles in the same material at different depths, the respective weights which they would safely carry would bear a direct relation to their lengths of penetration; this is under the condition that the upper portions have the same dimensions and tapering form.

At the Kirtland Street pumping station, where piles were driven in groups, the very common experience was had, that when a few of the piles had been driven as nearly together as practicable, the displacement of the material could not be adjusted by compression, so that in giving way along lines of least resistance the upheaval brought with it the displacement of piles previously driven. The same force which has lifted the ground surrounding the piles, has necessarily disturbed the conditions of rest and stability which had required ages to obtain, so that it can no longer bear the same weight as before without settlement. Sand which is practically incompressible after long ages of rest will again settle to a degree which, when undisturbed, could not possibly obtain.

In placing the load, therefore, we cannot depend upon the material around and between the piles to carry its share until after considerable settlement.

In the foundation of the Court House the estimate of cost is based upon the supposition that piles 25 ft. long are to be

driven 24 ft. Should additional lengths be required they are to be paid for at the same rate per foot. Let us make a proportion, and assume that the bearing capacities of the piles at the Court House and at the pumping station are proportionate to their lengths. The material designated as "clay" at the two places is of the same formation.

We shall have: As the lengths of the respective penetrations are to each other so is the weight which caused settlement at pumping station to that which will cause settlement at Court House site. Or, 35 : 24 :: 12 : 8.2 +.

But the pile driven 35 ft. failed to hold 12 tons without settlement, and no prudent engineer would assume that it could be safely loaded more than 10 tons, and, in fact, that would be too much. For sake of discussion let us assume that the long piles were to sustain loads of 10 tons each. We then have the proportion, 35 : 24 :: 10 : 6.8 +. This is less than one third of the average load which the piles must sustain if there is to be no settlement.

Let me invite attention to two groups of piles as arranged for outer and inner walls. Under the outer walls we have a large number of groups of 17 piles each; from the middle of one group to that of the next is a length of 11 ft. and 6 in., and the concrete footing to rest on the piles is 10 ft. wide. The footing therefore has a superficial area of 115 ft. The building code of Cleveland permits of loading "dry, hard clay or fine sand, compact and well cemented," with 4 tons to the square foot, and even permits the loading of the material "commonly called quicksand," when properly drained and undisturbed, with 3 tons per foot. A footing of 115 sq. ft., even under conditions not the best to be found, might be safely loaded to carry 345 tons, and if an equal weight be placed on the 17 piles which form the group, each must carry nearly 20.3 tons. This is three times as much as we have any reason to assume that the piles can carry without settlement.

Regarding the weights which the undisturbed sand can sustain with spread foundations, the amounts are so ample and well established by long experience as to be beyond the range of doubt save under conditions rarely found in Cleveland, and not at all in the area under discussion.

If the same area of footing was only loaded 2 tons per foot, it would carry as much as the 17 piles loaded to nearly 14 tons apiece. The experimental pile, 28 ft. 8 in. in the clay, notably failed to carry its load of a little more than 14 tons. By what

logic can we expect the shorter piles to hold as much without settlement?

Under most of the inner walls we have an arrangement of piles shown by the second sketch where the piles are staggered in two rows. The footings are 5.5 ft. wide and in a length of 15 ft. there are 10 piles. The area of footing for the 10 piles is therefore 87.5 ft. The same area of footing on the hard sand would readily carry 3 tons per foot if necessary. To carry the same weight as the footings alone would carry on the sand would require a weight of 26.25 tons per pile. At 2 tons per foot the footings on the sand would carry as much as the piles when loaded to 17.5 tons per pile.

When experience has shown so conclusively that the footings over these piles, if placed directly on the sand, would sustain without settlement a much greater weight than when on the piles, is it not folly to incur the expense of piling in view of the probable result?

One of the arguments which has been urged to favor the plan of a pile foundation for the Court House has been the alleged danger of a landslide which might carry the building, site and all, to some point nearer the lake. To substantiate this claim, which I have considered a "bug-a-boo" of an idea, certain unstable conditions remote from this site have been cited and enlarged upon. The most notable of these was the unfortunate experience of the Pennsylvania Railroad Company, in constructing a freight station on the high level close to the bank at Davenport Street.

I obtained the engineer's report of the sliding of the bank at that place, and of the methods employed to prevent further trouble so that rebuilding might proceed. These are the essential facts: At that place there are unmistakable evidences of several successive slides. It seems hardly probable that the one farthest from the bank would have occurred after it had been protected by other slides of earlier date on its front. It matters little in what order the slides have taken place, for resulting conditions are known. By successive slides the bank, which had doubtless originally been a steep bluff overlooking the lake, had been arranged in a series of terraces in which the corresponding strata of earth and sand could be clearly traced. On lines perpendicular to the bank, these strata were horizontal, and the successive parts formed a stairway from the lake to the high level above.

Between each two of these sections a deep crevasse was

originally formed, and these have gradually filled with silt and mud which permits the water to percolate and produce a constant outward pressure.

In building the station the outer wall had its footings on the upper portion which had previously broken away, and the other parallel wall was on the more solid ground of the high level. A large amount of sand was then placed on the terrace, to level the surface, and to afford more room for tracks. Soon an opening in the end wall was observed, and, in the hope of stopping the movement which was thought to be only near the surface, piles were driven in the terrace on the bank.

So far from helping the situation was the driving of piles, that it apparently caused the greater part of the slide by the jarring due to the fall of the hammer. A careful examination was then made and numerous borings disclosed the conditions to be met. A complete system of drainage was introduced with so much of improvement as to justify a continuance of the work.

Without knowledge to justify the argument, it was assumed that similar conditions would be found all along the lake front.

Opposite the Davenport Street slide, the tracks of the Lake Shore Railroad are 21 ft. above the lake level, and for many years have been so unstable as to require constant watchfulness and labor to preserve the alignment. This condition entirely disappears as we proceed westward, and westward of Muirson Street there has never been the slightest lack of stability in the tracks nor has there been any instability between Muirson Street and the river. The bank of the lake on this section has never shown evidence of instability, nor is there the slightest reason to apprehend any in the future.

The building site is not near a bluff, but is separated from the sloping bank on which is a city park, by somewhat more than the width of a broad street and from the bottom of the footings on the nearest front to the foot of the bank, which is several hundred feet from the nearest water of the harbor, the horizontal distance is nine times the difference of elevation.

There is no unstable soil on which to build, at this place, unless we needlessly go through the hard sand into the far less stable material which underlies it.

Where we have certain conditions and certain work to be done, there are two ways of proceeding. One is to try to adapt the conditions to the work, and this is not easy to do. Then to say that the conditions do not permit of our work is without good

reason. The other way is to adapt the work to existing conditions, and this offers no difficulty in the present case.

Let me seriously ask a question. In view of experimental information derived from practical work and experience, in view of these things which we know of a certainty here in Cleveland, does it appear best now to leave such solid ground of definite information and to start off on the unstable ground of untried experiment? — Not merely experiment for the purpose of obtaining information, though doubtless that would follow, but an untried experiment to use as a foundation for an expensive and monumental building.

## DISCUSSION.

Mr. Lehman. — We desire to express to you our sincere appreciation of your invitation to take part in the discussion of the subject treated by Gen. J. A. Smith on some phases of foundations for buildings in Cleveland. The subject is one of great importance and I will not attempt to treat the matter generally, but confine my remarks as nearly as possible to the conditions presented to us as architects of the Court House, to which we have given considerable study, using the information furnished by borings, aided by various books on the subject, by consultations with engineers and contractors personally qualified for this work, and governed by our personal experience and intimate knowledge of the building requirements, as to varying loads to be supported and the depths of the excavations of which I will give a description without the plans; these have not been presented as requested by your secretary, owing to a difference of opinion of the members of the County Building Commission regarding the advisability of presenting details which might be beyond the scope of this discussion.

The plan of the proposed Court House building is of such symmetrical design that the walls might be described as a series of semi-detached piers, the piers and openings throughout being planned in regular panels and units, so that the loads to be supported by the foundations have been calculated in the same way as the foundations for isolated piers.

The loads have been carefully estimated, and diagrams and sections of all the walls drawn, the loads figured for the respective walls reducing the panel loads in each case to a pier load. In these calculations for the loads on the foundations, the dead load only was taken into consideration, good practice having fully demonstrated that the maximum dead load, but only a small

percentage of live load, reaches the footings in a structure of this kind. For this reason only the actual weight of the material in the walls, floors, and roofs was considered as being the load which causes a settlement of the foundation during construction, the loads assumed for the bearings of the soil leaving a sufficient margin for all the live loads which might be added, but which will not affect the work until long after the walls have been completed and long after the foundations have taken a permanent settlement.

From test pits and borings made for the County Building Commission we are informed that the soil under the building is of various strata down to clay, which is found at an elevation of about 40 ft. above the datum line, and that this elevation varied about 5 ft. Above the clay is a layer of quicksand varying in depth from 2 to 5 ft. and above this, fine sand, clay, and sand, and clay mixed with sand; below the 40 ft. elevation the clay extends to the lake level practically the same. These borings indicate that we have no solid ground, such as rock, gravel, or dry sand, but that we have a compressible ground described as clay and watery sand and mixtures of the two. The basement floor elevation is at 56.78; the heater room and elevator pit floors at 50.78; and the foundations will extend below these elevations to various depths depending upon the nature of the construction. The surface water was found to be at an elevation of 52.3 ft.

From borings made by the county surveyor we have further information that the clay elevation varies 7 ft. in height over the building site; that it is high at the west end and low at the east; it is not of a uniform stratum, but is rolling in both directions, the general slope being diagonally across the building site in a northeasterly direction, and forming pockets with a variation in elevation of probably 5 ft. in 20 ft. These pockets would seem to be of quicksand and water, and fine sand and water varying in depth in the same manner as the clay. Above the quicksand is a layer of sand and water to the elevation of 52.3, giving us a bed of this material in the water of from 4 to 8 ft. in depth, so that our lowest floors are below the water line, and our basement floor 6.5 ft. above the same. The building walls extend 1 ft. below the floor line so that the foundations would be partly in clay, partly in quicksand, partly in sand and water strata, and others in the sand above the water line, with a bed of sand varying from 1 to 7 ft. thick for those above the quicksand.

Other considerations regarding the site are the 4 ft. in

diameter Ontario Street sewer running through the center of the building at about the basement floor level, an 8-in. water main running parallel to the same, a 42-in. water main on the north side of Lake Street, and the bluff not more than 100 ft. distant to the north. The possibility of a break in the Ontario Street sewer may be imagined, but it is hardly possible to conceive what damage such an event might mean. Such breaks have occurred and may again. This sewer we intended to have rebuilt below our footings. This would remove the obstruction as far as the building is concerned, but would only increase the danger on account of the new excavation and filling below the foundation, and not remove the permanent menace of the sewer. The possibility of a break in the 42-in. water main located not far from the south line of the building, and the damage which would occur if this were not discovered or shut off for several hours can better be imagined than described.

These are the conditions of the site of which Professor Baker, in "A Treatise on Masonry Construction," says:

"The foundation is the most critical part of a masonry structure. The failure of works of masonry due to faulty workmanship, or to an insufficient thickness of the walls are rare in comparison to those due to defective foundations. When it is necessary, on weak or treacherous soils, the highest constructive skill is required to supplement the weakness of the natural foundation by such artificial preparations as will enable it to sustain massive and costly structures in safety."

On this site we propose to erect a building, not the ordinary commercial, store, or office building, nor a factory, but a monumental structure to cost several millions of dollars; a massive building of unusual size, of substantial character, heavy walls and stability, and one that should be a monument for this community; and it should be so constructed that it will be a permanent, safe and artistic structure that will withstand all possible ravages of external and internal conditions so far as man can reasonably and safely provide.

Should such a building be erected on sand and water, a semi-liquid, such as mud, silt or quicksand, which good practice says should be removed entirely or have piles, tubes or caissons through it to a solid foundation, regarding which Professor Baker says, "Soils of a soft and semi-liquid character should never be relied upon for foundations whenever anything better can be obtained."

Shall it be erected on sand above a bed of quicksand, on a sand cushion where the imposing weight of the structure will

compress the soft material into the varying pockets of mud, and uplift the other lighter parts of the buildings, or where there is a possibility that the imposing weight would produce a pressure on the water, changing the angle of repose and forcing an outlet at some point of least resistance? This condition is not only a possibility, but one of which there is well defined ground for apprehension, and one of which the same author says:

"The determination of the safe bearing power of soils, particularly when dealing with those of a semi-liquid character, is not the only question that must receive careful attention. In the foundations for buildings, it may be necessary to provide a safeguard against the soil's escaping by being pressed out laterally into excavations in the vicinity."

If this is true, what will prevent the soil from being pressed out at this bank to the north,— conditions which have recently occurred with much lighter loads not far from this site?

Who is to assume the responsibility of experimenting with the most serious part of construction, the foundation, which should be the best? It should be uniform; it should have a uniform and equal bearing, and should be as near as possible at a uniform elevation.

As it is impossible to build an unyielding base, the object should be to secure a foundation that will settle as little as possible and uniformly; and to secure this end the axis of the load should pass through the center of the area of the footings. This cannot be done to such fineness of calculation as with a steel bridge construction, but the effort should be in the same direction and for as good reason; for the more nearly uniform the construction and bearings, the more nearly equal will be its settlement, and the more permanent its stability.

That there will be a settlement we must admit; but to keep that limited and uniform is our problem. In ordinary, every-day practice, we do not hesitate to remove any inferior soil we may encounter in an excavation to such depth as to secure a natural solid ground and fill in the excavation with clean sand or concrete, this depending always upon the character of our building; and our clients surely expect that we do so, and would rightly blame any architect or engineer for building over a known soft or inferior ground.

It has been said that if the ground were properly drained it would be a solid foundation. This is true to the extent that the drained area can be kept drained; that all surface and natural water will be permanently removed, and that no springs exist, and that no artificial leakage can occur. If this can be done,

authorities will agree that the ground is suitable, provided that the expense should not exceed the commercial value of the work done, and results obtained.

Below this sand, water and quicksand referred to we have a deep bed of clay of uniform consistency, fairly dry, with a sustaining power equal to any load we may wish to impose; a really fixed value for foundations, and it does not matter whether this clay is good for 1 ton per sq. ft., 6 tons per sq. ft., or any other fixed value. Its value can be ascertained, and when fixed provides the material we are looking for, — a uniform ground of great depth upon which calculations can be made with an assurance of such stability as its character and value permit, and the only foundation worthy of consideration.

If the clay is soft, Bauman says in his " Treatise on Isolated Foundations ": " We may consolidate the soft or unyielding ground by driving piles into it until it becomes so compressed that the piles are prevented from sinking by lateral friction."

We also quote from Freitag's " Book on Engineering," as follows: " Experience has shown that after clay has been compressed by a load of 3 000 lbs. per sq. ft. and allowed several months' repose, no very perceptible addition to that compression will result without a material addition to the load."

In view of the conditions as here established and the results of all of the information obtained, we have come to a conclusion and have submitted to the County Buildings Commission our recommendation for a foundation with piles of concrete, considering that an indestructible pile is essential in a ground containing water, and where there is a possibility within a few years of a change in the sewer system, that may lower the elevation of the water from its position to-day. This plan we have recommended, and we believe it to be a good and safe foundation for a building of this character that can be had at a reasonable cost on this site.

At this time it may not be improper to quote from a letter to the County Buildings Commission of April 5, 1905, by Gen. Jared A. Smith, referring to the borings for the County Building site, as follows:

" It may not be improper here to mention the probability that it may be found desirable to support the foundation of the building upon some indestructible material which shall extend to or into the hard clay substratum in such a way as shall preclude any reasonable possibility of injurious settlement."

Since the plans have been made, the Ontario Street sewer question has been taken up with Mr. Hoffman, and there is now a

possibility of this being removed and the sewer diverted so as to drain to Seneca Street.

In conclusion let me say that it seems but proper that the question of the stability of the Court House, and in fact the whole grouping scheme, should be thoroughly investigated, and that I hope the County Buildings Commission will some day be able to arrive at some plan that will be feasible with consistent economy, so as to maintain the artistic character of the group plan and prevent the possibility of there being a group of ruins in place of building.

Gen. J. A. Smith. — I would not impose upon your time further were it not that my name has been introduced, with a view, perhaps, to show an inconsistency in the fact that a man does not know as much one time as he does at another. In a more recent letter to the Buildings Commission, I stated that when that matter first came up I did think that it might be possible that we might require something better than we had, but I said that from that moment I had not passed a hole in the ground without examining it. I have not seen a building without looking for cracks in it. I have not heard of a source of information that I have not gone for it. I have talked, not with all of you gentlemen, because that would be beyond the range of physical ability, but have talked with quite a number of the civil engineers and with some of the architects, and so stated; but as some of the commission seem to think that that was second-hand information it seemed best to get it at first hand and I have got that now.

[General Smith here read quotations from different letters.]

Mr. Osborn says, " My judgment is that the conditions and situation require that a spread foundation be adopted."

Mr. Ritchie gives me essentially the same thing, covers the same points. In order to get this officially I went to the city engineer. [Reading.] " I would consider the soil at 20 ft. capable of sustaining a load of 2 tons per sq. ft. without any danger and would not consider it necessary to use piling with such load."

Walter Rice tells me he has carefully digested all these available data and says, " I have no hesitancy in stating that the solution of the problem lies in deep drainage, the foundation of the building to rest thereon." After Mr. Rice had written that letter, I said to him perhaps there were not any two people who would give the same interpretation to " *deep drainage*," and he turned over the sheet and wrote:

"*My reference to deep drainage in the above means drains to be not less than 2.5 ft. below the footings.*" In other words, he meant to drain the water from them, so that if you come clear down to that very fine sand, even the most timid need not be afraid.

The Cleveland Engineering Company states substantially the same, and tells me about the weights underneath their columns in the Arcade power plant, and the fact that in boring their holes for the foundations of their building in Hickox Street, the borings were made with a 4-in. auger and in none of the borings were casings used, and yet each time the auger was put back it reached fully to the depth it reached before being taken out.

Perhaps you will bear with me a little more. We read somewhere of people who walked on the water. None of us have been able to do it much this winter, but when you get a little ice on the water you have something that is a fair illustration of a hardened coat of sand over a soft material, and when you get a few inches, a horse may walk on the water. Many years ago, twenty-four or twenty-five years ago, I commenced the work of one of the heaviest lighthouses on the Atlantic Coast, 60 miles south of St. Augustine. I had been telegraphed for to take the place of General Babcock, and I found the lighthouse in the condition that it was built up to the surface of the ground. I hunted up the borings and found from 12 to 15 ft. of a sand that was nothing like as hard as sand we have here, but was made of broken shell and pulverized coral. That sand overlay a swampy condition. To detect settlement should it occur I had 4 holes dug in the sand 3 or 4 ft. deep and bricked up like a well. A concrete foundation was put in the bottom of each of these holes, and on that material stones were set for bench marks. Observations were made daily but no settlement was detected. Last winter I was up on the top of that lighthouse again where it has stood for more than twenty years on a coat of sand overlying a swamp and there has not been one particle of disturbance in its foundation, notwithstanding it has stood in the vibrations of the heaviest winds that frequently traverse the coast.

Mr. Hanlon. — No doubt there are a great many yet who would like to take part in this investigation, but the hour is late and I move that the further discussion be postponed for two weeks, when we have a semi-monthly meeting and we can take up the subject again.

Mr. Lehman. — I would like to suggest to the members of the Club that as they are trying to take this up they address

the County Building Commission for permission to take the plans and have them here and go at the matter in a systematic way. If this club wishes to get at the facts let us get at the question in discussion.

PRESIDENT GREEN. — The discussion was to be a general discussion of foundations, although, of course, the Court House site and foundations are of general interest to all.

B. F. MORSE (*read by Secretary*). — During the last meeting of the club, February 13, 1906, Gen. J. A. Smith in his remarks about foundations of buildings in Cleveland, referred to a test pile that had been driven down on the site of the proposed new County Court House. A pit was excavated down to ground water level, 20 ft. 4 in. below the grade of Summit Street to an elevation of about 48.8 ft. above the water in the lake. The pile was 37 ft. 4 in. long, 15 in. thick at the butt and 8 in. at the point. This pile was driven with a hammer weighing 2 680 lb., falling 21 ft.; during the last 4 blows the penetration of the pile averaged per blow 1.56 in. After the pile had been driven, the pit in which it was located was excavated deeper, about 9 ft., leaving so much of the pile above the bottom of the pit. The pile was then loaded with over 14 tons. In two weeks it had sunk 3 in., and during the last two days it sank more than in the previous twelve days. It occurred to the writer that it might be interesting to the club on this occasion, and perhaps aid somewhat in the discussion of the subject matter of General Smith's remarks on foundations, to give a brief history of the pile driving under or in the foundations of the Superior Street viaduct on the west side of the river.

Commencing at the west end of the draw or swing bridge at pier No. 8, thence westerly, there are 8 arches 83-ft. span and 2 97.5-ft. span. There are piles under 9 piers from pier 8 up to and including pier 17. These piles were from 30 to 45 ft. in length and were driven with a 2 500-lb. hammer, which for the last blow had a fall of 40 ft., causing the piles to sink on an average of 3 in. in pits 8 to 13 inclusive. In these pits on the river flats the material was composed of sand, river silt and mud for a considerable depth, mixed in different proportions even in the same pit. Occasionally the sand would be nearly pure in a limited area and 4 or 5 ft. in thickness, and frequently when a pile showed great resistance in passing through, it then would go down 8 to 15 ft. before it would again show the same resistance. This lack of uniformity made it necessary to change frequently the length of the piles, and also to vary their distance apart, to

get the requisite supporting power to carry the superstructure. Pits 14 to 17, inclusive, were entirely in the blue clay, apparently the same as on the east side of the river. The piles went down under the last blow in these 3 clay pits on an average of 5 in. In pit 14, the resistance was less than in the others.

The first piles were driven in the northerly end and when the driver reached the southerly end, a distance of 80 ft., the piles first driven had risen from 6 to 8 ft. and from that down to less than 1 ft., as they approached the southerly end of the pit. After standing about two months they were driven to the original depth, offering twice as much resistance in the second driving, as in the first. In some of the other pits the piles rose, but not as much as in 14.

In pits 8 to 13, the earth became consolidated in driving and offered greater resistance as the work progressed. But in the blue clay the last pile drove as easily as the first. Piles in pit 14 were driven 27 in. between centers and in the others from 28 to 36 in. The total lineal feet of piles used in the building of the viaduct was 242 767 ft.

The piles were cut off below the surface of the water in Lake Erie, and the material in and around the heads of the piles was excavated or removed to a depth of 1 ft. and the space filled in solid with concrete which was leveled off even with the top of the piles; then oak timbers 10 by 12 in. square were laid on top of the piles, leaving a space of about 1 ft. between them; these spaces were filled in solid with concrete and leveled off with the top of the timbers. Then a grillage of 10 by 12-in. oak timbers laid close together was laid crosswise on or over the entire surface; on this grillage the masonry was built. The permanent weight on some of the piles is as much as 20 tons; and the weight per sq. ft. of surface covered by the footing courses in some of the foundations exceeds 5 tons.

Test levels were taken on the footing courses of all the piers and abutments before and after they were built up to the springing line of the arches at intervals of from six to twelve months, until the viaduct was completed, the roadway paved and the full or permanent load placed upon the foundations, and yearly thereafter up to 1882. The viaduct was completed and opened to public use December, 1878. The first test levels were taken November, 1875. A period of about three years elapsed while this part of the viaduct was being built, and the settlement that took place during the three years as shown by the test levels was 2.5 in. at pier 8 and 3.5 in. at pier 14, the others

ranging about the same between the two. In the solid clay, foundations under piers 15, 16 and 17, the settlement was 5 in. From the time this viaduct was completed, for a period of four years afterwards, only about $\frac{1}{2}$ to $\frac{5}{8}$ of an in. settlement had taken place, as shown by the test levels.

During the building of the Walworth Run sewer, which for the greater part of the way is built upon this kind of blue clay, two expensive and scientific tests were made to determine its supporting power. The conclusion arrived at was that not more than 2 tons per sq. ft. could be applied to this kind of materials without danger of serious settlement. (See report of Mr. Walter C. Parmley, on the Walworth Run sewer, published in *American Society of Civil Engineers Transactions*, for August, 1905.)

From the above experiences, it appears that piles driven in this blue clay will not carry as much of a load as the sand and gravel overlying the clay, which agrees with the conclusions arrived at by General Smith. In the proposed new Court House and City Hall, the outside walls will be thicker and heavier but not nearly as high as some of the skyscrapers up town, so that the weight on the foundations of these proposed structures need not be any more than under the skyscrapers. The Society for Savings building is proportioned for 2.5 tons per sq. ft. on the foundations and they are only 12 to 14 ft. below the sidewalks, entirely above the ground water level. In the New England Building, the highest in the city, the foundations are not excessive, neither are they in the Rose nor Schofield buildings. They show no signs of settlement as yet.

From observations and experience, the writer believes foundations resting on the sand above the water and down into it, if they are not loaded over 3 tons per sq. ft., will be perfectly safe, and will not be as expensive as piles.

As to any danger of caving or sliding off the bluff northerly of Summit Street, or farther south, the writer knowing the conditions that have existed and taken place on the Lake front since 1851, especially between Seneca and Erie streets, has no hesitation in saying that in his judgment it will be perfectly safe not to use piles under these new buildings.

It is true that previous to the building of the railroad tracks and stone and pile breakwater, just outside of them down at the foot of the bluffs (but not since), landslides used to take place frequently, caused by the undermining action of the waves of Lake Erie during the storms from the northwest or northeast.

I could refer to many other foundations but I do not wish to take too much of your time.

I trust you will pardon me if I now digress somewhat from the matter under discussion, though rather late, to the life and cost of the proposed public buildings. Why should we build such expensive buildings when, judging from the past, most of them are too small or out of date inside of thirty or forty years?

For instance, take the old Court House, northwest corner of the Public Square, completed in 1858, only forty-eight years ago. At that time it was considered A No. 1. It has been enlarged and improved and is still very unsatisfactory. Then take the recent addition on Seneca Street; it was occupied in 1875. At that time it was considered a grand affair. Then again take a look at the present City Hall. At the time it was completed in 1875 it was, for this part of the country, a fine example (from outside appearance) of Mansard roof construction. The cut-stone work of the exterior is first-class; although the proposed new buildings will be of a different order, I doubt if the cut-stone work will be equal to it; yet there is talk of tearing it down in the near future. All these old buildings are not what is wanted now. All of them are deficient in light and ventilation in their interiors. But you may say that the most modern buildings that are being built now cannot be exceeded.

Suppose an architect or an engineer, fifty or even thirty years ago, had said the day would come when you would see the construction commence at the top story in laying brick and terra-cotta work, or at the third story and work upwards, which is a common occurrence now-a-days. You would probably have thought him a proper subject for an insane asylum.

I could refer you to buildings in other cities that are out of date which are to be replaced. In fact, it is a common occurrence in this country, and if they are to be cast aside in thirty or forty years or even fifty years, why spend so much money on them?

President Green. — Mr. Morse's discussion is very interesting. We have a lot of people with us to-night who are interested in this subject and a lot of people who have valuable information to give us. I trust we may have an interesting discussion. I shall be glad to hear from anybody.

Mr. Lehman. — In regard to the test pile that Mr. Morse refers to, and also the same one that General Smith spoke of, I just want to say that the failure of that pile was not due to the loading. As Mr. Morse explained, that pile was extended to about 9 ft. above the pit. When the extreme settlement

came after the load had been put on, it was discovered that the pile was tipping and at that time the loading was abandoned. The pile as a *test* pile was a failure.

Mr. Hoffman. — I think there is a point we should not lose sight of in speaking of pile foundations. I speak of the large number of piles driven in the pits of the viaducts. The first drive was 2, 3 to 4 in.; the second driving was much less. It shows that the ground becomes closely compacted by driving a large number of piles in a limited area. I think it is a little far-fetched possibly to attempt to draw too many conclusions from the single test pile. It seems the only way to do is to drive a a cluster of them at least and get the increased bearing and not to draw too many conclusions on one pile. When you have a large area under consideration you certainly get different results from what you do when it is a small, limited one.

Mr. Morse. — In regard to pit 14, if the piles had been re-driven immediately I think they would have gone down much easier; but after standing two months they were re-driven with difficulty.

The Secretary. — I have some notes here that General Smith telephoned to me this afternoon. He is sick and has been confined to his home for several days and cannot be here.

In the first place, he presupposes that the piles as designed for the Court House foundation are limited to 24 ft. in length; and from further information he has ascertained, or at least he deduces, that in the interior of the Court House there would be as wide a variation as from 14 to 24 tons per pile, and on the outside walls as wide a variation as from 15 to 30 tons for a single pile. He cites again the Kirtland Street smoke stack, which was put up on a pile foundation, these piles being 35 ft. long. On these piles there is a weight of 12 tons per pile. There has been a settlement of from 0.5 to 1 in. and very unequal, the weight having been equally distributed.

He makes the further point that in the Court House an average of 21 tons is estimated for, and this is very unequally distributed, so that he figures it is probable that the weight on one pile as designed might be 90 per cent. less than the weight on other piles.

[N. B. A careful examination of the plans since the above discussion, by General Smith and myself, shows a variation in load of from 15 to 38.4 tons per pile. — Secretary.]

Mr. Lehman. — I am sorry General Smith is not here, because what I have to say I would like to have him hear.

In the first place, I will say that I do not know where he got those figures from, but they are not right. The Court House piles are figured on as nearly as possible at 25 tons to the pile and not at 24 ft., but 30 ft. long.

As I said two weeks ago, I was sorry that I could not bring the drawings of the Court House here, and it was our intention to bring them. Five members of the committee were very willing that the details and the plans should be brought here and explained to the club, but two members objected, and I do not hesitate to say that General Smith was one of them, and one of his objections was that the probability was that his paper would not take up the details of the Court House specifications or plans, and that the details of the building would probably be beyond the scope of that paper and ought not properly to be discussed here; and another member of the commission also objected to the plans being brought here because the plans had not been adopted by the commission.

The facts in regard to the Court House foundations are about like this: In the first place, we laid out a foundation for that building with the beams going across the walls and constructed you might say almost practically as isolated piers. The only connection is a little strip under the opening, probably 3 or 4 ft. long; and then we are figuring for a uniform load notwithstanding any remarks General Smith or anybody else may make. We have diagrams to show the load of every pier in the building, not only sketched out but drawn out, and the loads carefully figured, and those loads are all submitted to the engineers who designed the foundations. I think they are figured as near right as can be on those loads.

Those plans included a deep draining system outside of the entire building, probably 10 ft. beyond the area wall, which would bring it probably to 25 ft. away from the main wall of the building; and this drain went down into the clay with a sewer pipe at the bottom and a stone and cinder filling and a complete drain to the sewer to keep the entire site of the building as dry as possible. That was the first plan, but that was finally abandoned for the reason that there was no assurance that the drainage system or that deep drain that we had there could be maintained. It would do all right for a little while, but nobody could say how long that would keep the place dry, and after a great deal of figuring a pile foundation was designed and estimated on; and the difference between the cost of the grillage foundation with the drain and the pile foundation without the drain, was not

so much as to make an impression on a building of that size. That was the plan that was submitted with the drawings.

The Buildings Commission had that plan under advisement for some time and finally sent us a communication instructing us to eliminate all specifications regarding pile foundations and insert therefor a specification for a concrete spread footing foundation with 9-in. drain 2 ft. below the footing and 6-in. branch drains every 20 ft. along the building connected to the 9-in. pipe and the 9-in. pipe to drain into the sewer. That was specified in detail by General Smith's resolution.

We prepared a foundation plan of that kind. Then they considered that plan. We have a fourth foundation plan for the Court House now, where the footings, instead of being isolated, are continuous, connected both ways so as to make it sure they cannot get away. That is the last plan. This last one is without drains. General Smith thinks that is pretty good even if there are no drains in it. He thinks, too, that a grillage foundation might be good even without drains but a spread footing of concrete only would not be any good without drains.

General Smith, in speaking of the Rockefeller Building, said that they bored a hole I don't know how many feet below the foundation and no water could get into it. He also said that if you would drive piles on the Court House site the water would percolate all the way down those piles. I would say that the plans for the Court House do not say that any single pile is to be tested. They are to be tested in groups of four. The piles are estimated at 30 ft. long.

The Secretary. — What was the difference in cost between the grillage foundation and the pile foundation?

Mr. Lehman. — I have not got the figures and I do not want to be quoted in figures without the direct estimates, but I think one figure that was given out, the difference between a pile foundation and the concrete foundation without drains, was $56 000. The difference between the grillage foundation with the drain I do not remember, but the pile foundation is more expensive than the grillage. I do not know just the exact amount, but there was much more steel in the double grillage, and proportionately more concrete.

Mr. Olmstead. — What was the level of the base of its foundations as regards the adjacent streets and also the lowest level of basement?

Mr. Lehman. — The grade elevation there is taken at 70.5. I think our basement floor level is 56.78 and the elevation of our

heater rooms is 50.78. The elevation of the surface water there, 52.3. The wall itself is about 1 ft. lower than the floor; 50.78 is our lowest, whereas the grade elevation is 70.

PRESIDENT GREEN. — Mr. Lehman, in the test of the ground, do you remember what the average elevation of the clay is?

MR. LEHMAN. — The elevation of the clay at the west end of the building I think was 45; in the center of the lot 42 or 43, and at the east end 40, and by other borings made at different parts of the building we have a variation anywhere from 40 to 47 ft. and that varies sometimes; one pit will be 40 and another, 30 or 40 ft. away, may be 45 or 43 or 44 ft.; these pits were made on a line north and south; the elevations of these go to show, I think, the highest point is near the center, 47; 45 at the west and about 40 at the east and the general slope of the clay is in a northeasterly direction, diagonally across the building.

PRESIDENT GREEN. — I do not know whether I can say anything at all new to the members, but, illustrative of the point of the whole matter, we might have before us a few points regarding the subsoil through Cleveland in this territory as follows:

Quite a number of tests have been made in different places and those tests combined with the reports of geologists agree fairly well that the subsoil from the surface is sand, growing generally finer as you go downward, for varying distances of perhaps from 25 or 30 to 50 ft. below the surface; that at some point between those limits, the dark, hard and fairly dry blue clay is reached which is known hereabouts as the Erie clay, and that that clay continues generally to a depth of 120 to 200 ft. below the surface, that is, making a total thickness of the clay of perhaps 60 or 70 to 150 ft. That clay is generally reported to be somewhat stratified in its nature and generally quite dry. It contains occasional pockets, sometimes of quicksand and sometimes of a finer and more moist clay and occasionally of shale formations. The peculiar stratification of the clay is indicative of the Erie clay; underlying that is the Erie shale, which is quite thick. It is that dark blue, slaty sort of rock, often called soapstone, that has the peculiarity of disintegrating on contact with the air. It is quite hard when first uncovered but will go all to pieces in a short time on exposure to the air. I have seen that checked up in a number of places; that is, so far as the Erie clay is concerned.

In the flats where two deep borings were made below the

level of the flats, the clay is much lower, and one goes through sand of quite varying consistencies and mud and all sorts of things; one hole that was put down at that point was driven 48 ft. through casing and, inadvertently, the boring tool was allowed to get pretty close to the bottom of the casing and we never got the tool back. It stuck too tight to pull out. The soft muck and quicksand of that territory came up and filled the casing nearly to the surface. The sand through most of this business district is a reddish yellow color, growing somewhat finer with the depth, and after getting into water-bearing stratum becomes a bluish gray color.

We have then a sand soil 30 to 50 ft. thick, with clay underlying it. The clay is dry, the sand in its lower part is wet and is dry above.

So far as any tests that have ever been made are concerned, the bearing power is good throughout the sand, in fact, the bearing power is a little more secure on the sand than in the clay, and I think the members will bear me out in the statement that, as a general rule, sand is a better bearing soil than clay, even though the clay may be fairly dry. The sand if it is wet is a better bearing material, provided that the fine sand, when it is wet and mixed with enough lubricant to make it what we commonly call quicksand, is confined laterally.

I think the point that General Smith brought out of the percolation of water running down the side of the piles in clay was about right. Piles will drive easier in clay than in sand. We all know that clay is a very poor bearing soil if it is at all wet. The surface of the clay against the pile becomes greased with water that is carried down with the pile. My understanding of the geological condition of the moisture of a good deal of the soil hereabout is that the water lies on top of the Erie clay in pockets or low places on that surface.

Mr. Lane. — It is a little bit off the subject, but in regard to the geological condition of the actual valley here, the original mouth of the Cuyahoga River was along Willson Avenue and was about 500 ft. deep at that point. In drilling gas wells they went 500 and some odd ft. before striking the shale, and less than one mile east they struck the shale at about 45 ft. From drillers who have drilled over a hundred gas wells in that district, I have heard that the old river bed is filled with silt and clay, and there are some pockets filled with quicksand. Our city is fortunately located in that our heavier buildings are on shallower depths of the Erie clay. If we were 3 miles east-

ward, it would be on the solid shale. The Erie clay is a glacial formation.

Mr. Lehman. — I would like to ask Mr. Morse a question. There have been banks recently that have slid off west of here out along Lake Avenue. We know that the bank there has slid off into the lake in pretty good chunks. It may be possible that Mr. Morse may recall that about fifty years ago there was an immense slide all along the lake and that it went down north of here 25 ft., and that practically the whole bank along the whole front of Cleveland went down at that time. I was wondering if Mr. Morse would remember anything about it.

Mr. Morse. — The bank did not go down uniformly the whole length, but would go down in sections, 100 or 200 ft. long; some would be 10 ft. on the surface and some may have been 20 ft. wide, more or less, but that was before any piles or railroads were built down there, and there were no depots or breakwater out there, and the waves came in during storms and undermined the foot of the bluffs, and they would slide down in places at different times. When the water was very high, as it was at one time, the banks caved away much faster; but since the railroads have built there and the breakwater is just outside the railroad tracks, the waves cannot get at the bluffs, and there have been no slides.

Colonel Whittlesey says that Erie clay is shown to be principally a fine sand with clay enough to cement it. It also contains lime enough to give it a lime character and when soaked in water becomes soft and yielding like quicksand. I know from experience; I have worked a good many times in this blue clay. When we were building the depot we had a steam shovel, and in places it had to be picked down by hand, that is when working it from a perpendicular face; but you take off the sand and gravel on top and you can shovel it up. There is a little moisture in there, and by putting on teams and driving over it, it works up and you can shovel it; but if you work it down below, you have to pick it down.

Mr. Lane. — The action on that Erie clay can be observed in the present mouth of the Rocky River. It is Erie clay with gravel overlying and you will find every year the waves undermining the Erie clay and chunks of the bank sliding down. There were two marked slides there last year. The same thing must have occurred here at the time the lake could get at the bank. But now that the bank is protected I can see no way for it to slide. I do not believe a man could pile enough on it to

make it slide. But a little bit of undermining would take it down.

Mr. Schowalter. — From the last paper I had this impression, — that there was fear on account of settling that might be caused by the pockets of quicksand which General Smith tried to prove was not quicksand. I notice that the Baltimore & Ohio Railway have made their tunnel in Baltimore secure from quicksand dangers by driving pipes every 100 or 200 ft. along the tunnel and pumping cement gravel in the quicksand, thus solidifying it. That was about a year ago, and previous to that the water had found its way along the tunnel and carried along with it some of the quicksand and caused some settlement along the right of way, and the city compelled the railway company to do something to prevent the water carrying the quicksand along the tunnel and this was what was done. I should think, in a foundation, wherever it is placed, if this is possible along the tunnel it could be done here. If there is any danger of quicksand it is an easy matter to run pipes into it and solidify it.

Mr. Olmstead. — As regards draining of the foundations and also concerning solidifying quicksand, I was interested in watching the construction of the Erie Street sewer. The Erie Street sewer ran into sand which, if not a quicksand, was a mixture of sand and water which I should call a quicksand. There are no drains I believe under this building. There are no drains I know under the Citizens Building and there has been no settlement there, although the foundations are grillage foundations laid on the sand. It is presumable that the conditions are the same in the one next to it. It seems to me that that has a bearing on the necessity of drains under any foundation of grillage conditions such as we have under the Court House.

## PROPORTIONING CONCRETE.

By Sanford E. Thompson, Member of the Boston Society of Civil Engineers.

[Read before the Society at an informal meeting, February 14, 1906.]

As the uses for concrete increase, the necessity grows for a greater economy in construction. To reduce the cost of materials one naturally considers the use of leaner proportions. To decrease the proportion of cement without corresponding loss in strength the aggregate must be specially graded or such materials selected as will increase the density of the set concrete.*

Just how far it is economical to go in increasing the density depends upon the conditions. If, as might be possible on a small job, the cost of materials is reduced 10 cents per cu. yd. by substituting a leaner but denser mixture, and, at the same time, if the cost of labor of preparation is increased by 15 cents per cu. yd., it is obviously poor economy. It may, in fact, sometimes cost more in time and trouble and materials to make a lean concrete of high strength than to attain the desired result by using more cement and the materials nearest at hand.

On the other hand, if a large mass of concrete is being laid per day, it may be good economy to spend money for special tests and provide extra machinery for preparation, and even to pay a higher price for the sand or stone in order to secure that which is best suited for the work. The question then is one which must be settled by estimates of cost, and the size of the job is the chief determining factor.

However, special grading of materials is a matter which interests us much less frequently than the practical selection of proportions for structures where the choice of aggregates is limited and the character of the concrete such that the problem is simply one of selecting the best relative proportions of the available coarse and fine aggregate, or, perhaps, comparing two materials which may be obtained at trifling difference in cost.

* The term *density* I use in its now generally accepted meaning, as the ratio of solid particles in a unit volume of concrete. It is thus the complement of the voids. For example, if a piece of concrete has 15 per cent. voids (including the air and the water), 85 per cent. of its volume must be solid material, and its density is 0.85.

Therefore, before considering the effect of different characters of aggregate, we should first study the experimental methods for proportioning two materials and for simple comparisons of quality.

In experimental determinations for selecting proportions it is a generally accepted fact that for maximum strength we should aim at a mixture having the smallest percentage of voids, but it is by no means settled as to *how* this result shall be obtained even experimentally. For convenience in studying the question we may classify the various plans which are followed.

(1) Arbitrary selection; one arbitrary rule being to use half as much sand as stone, as 1 : 2 : 4 or 1 : 3 : 6; another, to use a volume of stone equivalent to the cement plus twice the volume of the sand, such as 1 : 2 : 5 or 1 : 3 : 7.

(2) Determination of voids in the stone and in the sand, and proportioning of materials so that the volume of sand is equivalent to the volume of voids in the stone and the volume of cement slightly in excess of the voids in the sand.

(3) Determination of the voids in the stone, and, after selecting the proportions of cement to sand by test or judgment, proportioning the mortar to the stone so that the volume of mortar will be slightly in excess of the voids in the stone.

(4) Mixing the sand and stone and providing such a proportion of cement that the paste will slightly more than fill the voids in the mixed aggregate.

(5) Making trial mixtures of dry materials in different proportions to determine the mixture giving the smallest percentage of voids, and then adding an arbitrary percentage of cement, or else one based on the voids in the mixed aggregate.

(6) Mixing the aggregate and cement according to a given mechanical analysis curve.

(7) Making volumetric tests or trial mixtures of concrete with a given percentage of cement and different aggregates, and selecting the mixture producing the smallest volume of concrete; then varying the proportions thus found by inspection of the concrete in the field.

Still further variety in methods is produced by different handling of the stone and the sand, some engineers measuring the voids in the stone loose, while others compact the stone to a greater or less degree. Other complications are introduced by the different methods of determining voids, whether by pouring water into the stone or sand, pouring the stone or sand into

water or weighing and calculating the voids from the specific gravity.

After the proportions have been selected, the questions arise as to whether we shall frame the specifications to require loose or packed measurement of the aggregate, loose or packed or arbitrary measurement of the cement, or weight measurement of all the materials; or shall the specifications state that the concrete shall contain a certain quantity of cement in a cu. yd. of concrete? Shall we adopt two aggregates, merely sand and stone, or shall we mix two grades of sand and two grades of stone? These are some of the problems which confront the man who would proportion his concrete for maximum economy.

At the outset we must admit that the nature of the materials used in concrete, the daily and even hourly variation in the quality, sizes and percentage of moisture, prohibit absolute accuracy either in fixing proportions or in practical measurement of materials. Yet different methods of testing for the purpose of fixing proportions in advance may produce, with the same materials, as great variation as between 1:2:4 and 1:3:7½; surely such possible variations are not to be ignored. Differences in the methods of measuring proportions by the contractor may produce nearly as great variation.

It may be well to review first the causes of the variations in tests for proportions, the sources of errors and the part which good sense and careful judgment must play in the matter. Suppose we consider what may be termed the ordinary method, which is most commonly given in print and employed quite widely in practice,—the method of first determining, separately, the voids in the stone and the voids in the sand, and then proportioning the volume of the sand equivalent to the voids in the stone and the volume of cement slightly in excess of the voids in the sand. The chief variation in the stone, if it does not contain sand or dust, is due to the degree of compacting. Some adopt loose measurement and others packed, while many use slightly shaken measurement. One man may measure broken stone *loose* and find 50 per cent. voids, while another may take the same broken stone and, compacting it, obtain 40 per cent. voids. The proportion of sand in the two cases, if selected strictly by the test, will vary accordingly. The size of the measure also affects the voids.

The voids in stone above ⅜ in. may be correctly determined either by pouring in water, or by weighing and calculating from

the specific gravity. In either case, if a porous stone, correction should be made for water absorbed in the pores. Most rock in this vicinity is so dense that this absorption may be neglected. If the stone contains dust, even a small proportion, the air is held in the pores and inaccurate results are reached. Accordingly, for fine material, it is more accurate, in fact necessary, to adopt the weight and specific gravity method. This is also the simplest method with sand, as the specific gravity of sand averages about 2.65. In the vicinity of Boston I have found it slightly higher than this, ranging near 2.7, probably owing to the pieces of trap and other heavy rock contained in it. Either figure is sufficiently accurate to use for void terminations, provided one desires to test the voids. The moisture in the sand must be corrected for by drying a sample and determining the percentage of moisture.

It is thus comparatively easy to find the voids, both water and air voids, in a certain sample of sand, but when we come to figure from these voids the proportion of cement to select, we meet with a greater difficulty than in the relation of the stone to the sand. How shall we select the sample of sand? Shall it be dry or moist, loose or shaken, measured in a small measure or in a large one? Every one of these variations will give a different ratio of cement to sand. Examples of actual tests in my laboratory show that in ordinary bank sand with natural moisture, there may be a difference as great as from 53 per cent. voids when the sand is measured loose to 42 per cent. after shaking.

The effect of moisture on Cowe Bay sand came to my notice in a practical way in connection with tests at Jerome Park Reservoir last winter. In order to make an entry upon one of the tables, although not for direct use in the experiments, as we considered that a knowledge of the voids in sand was of little value, a sample of sand which had been dried in the laboratory was weighed. Its weight was found to be 103 lb. per cu. ft., corresponding to 38 per cent. voids. The same sand was then placed out of doors during a rain, and after lying in the sun for two days following, was retested, and found to weigh 83 lb. per cu. ft., corresponding to 52 per cent. voids. By the theoretical method of proportioning, in one case the proper mortar would be about 1:3 and in the other case about 1:2, and yet the sand was the same and, therefore, the 1:3 mortar would have been only about two-thirds as strong as the 1:2

I made the statement a few minutes ago that different

methods of testing might result, with the same materials, in proportions as widely different as 1:2:4 and 1:3:7½. The case cited shows this difference in the mortar. The difference in the ratio of sand to stone (*i. e.*, 2:4 in one case and 3:7½ in the other) may be reached on the one hand by measuring the stone loose and finding 50 per cent. voids, and on the other by compacting it before measuring the voids and finding 40 per cent. voids.

Perhaps I have dwelt too long upon the inaccuracies of proportioning, but it seems to me that this is a matter of the greatest importance to us in order that we may avoid such inaccuracies, or, at least, exercise very careful judgment in drawing conclusions from them. For example, in the case just mentioned, which is correct, the 1:2:4 or the 1:3:7½? In other words, shall we measure the stone loose or compacted, and shall we measure the sand dry or moist? Or shall we throw aside this method of determining proportions and select some other? As I shall suggest presently, personally I do not place much dependence upon the determination of voids in the different dry materials because of the variations I have mentioned. However, some information may be gained from such tests if the character of the materials is taken into consideration and the methods made to apply to them. For certain materials, for example, the stone may be compacted before measuring the voids and the proportion of sand thus formed, measured loose, will be sufficient to fill the voids when making the concrete. This is the case when the stone is coarse and of fairly uniform size, such as 1½-in. macadam stone, and contains no small stone. The voids are then large, and particles of ordinary sand will fit into them. On the other hand, if the stone is crusher-run, even with the dust screened out, and the sand contains a large proportion of coarse grains, many of these grains will be too large to fit into the smaller voids of the stone, and, therefore, will increase the bulk. Consequently, a larger quantity of the smaller grains must be had, and to do this, the total quantity of sand must be more than enough to fill the voids in the compacted stone. This question of the relative sizes of the grains, which I think was first brought to notice by Mr. William B. Fuller, is frequently neglected in fixing proportions.

This principle is well illustrated in the use of gravel and sand screened from it and remixed. Ordinarily screened gravel, measured loose, has about 40 per cent. voids, so that one would naturally expect a mixture of, say, 1:2:5 to work satisfactorily. If the gravel is compacted so that its voids are 32 per cent., the

theoretical mixture would be 1:2:6. However, in practice, the grains of the gravel and sand overlap each other, that is, the smallest grains of gravel are smaller than the coarsest grains of sand, and the voids in the gravel are consequently too small for the large sand grains to enter, so that it is sometimes necessary to use half as much sand as gravel in order to prevent large voids in the concrete.

Experiments by Mr. Rafter, which are of very great value and have been widely quoted, show a surprisingly small proportion of sand. He used 35 per cent. mortar and 40 per cent. mortar both in test and in practice; *i. e.*, the volume of mortar was 33 per cent. and 40 per cent. of the volume of stone slightly shaken. Now, even the larger per cent., 40 per cent. mortar, corresponds to proportions with as little sand as 1:2:6, which probably none of us could use with our New England sand and make good concrete. Our materials would require a 1:2:5 or 1:2½:5 mix. However, if we examine the analysis of Mr. Rafter's sand, we find that 92 per cent. of it passed a No. 30 sieve (30 meshes per linear inch). The grains were thus small enough to enter the voids of the stone without appreciably increasing the bulk; in fact, in many of Mr. Rafter's tests, the volume of the concrete was considerably less than the broken stone slightly shaken. His sand, although apparently so fine, was not of bad quality for concrete work, because there was very little dust in it, and therefore the cement entered the sand voids.

We are coming now to one of the principal points which I wish to make in considering this subject of proportioning. The cases cited show that the experimental void determinations cannot be expected to give practical results, but various allowances must be made. Now, why not, instead of making tests one way or another, guessing at the best way to handle the materials and then altering the proportions by judgment, why not, in the first place, or, at least, after rough determinations to serve as a basis, make up trial mixtures of the materials with the stone and sand and cement and water, and determine, from the appearance of this mixture and the quantity of concrete made from it, and, to go a step further, from the density, or, in other words, the percentage of air and water voids which it contains, whether the proportions are correct? If only two materials are available, the proportions of sand to stone may be determined, after selecting the percentage of cement, by mixing the materials in several proportions and selecting the one giving the smallest volume with a given weight of aggregate (corrected, if necessary, for differ-

ence in specific gravities); also, judging by the appearance of the mixture, taking care on the one hand that there is sufficient mortar to fill the voids in the stone,— that is, that there is a slight excess on top when lightly rammed,— and, on the other hand, that this excess is not too great. The appearance of the concrete also should not be coarse, but there should be enough cement and fine particles of sand or dust to fill the pores and make a fairly smooth mortar.

In the field, this method of inspection is also applicable. In laying the reservoir bottom at Jerome Park, New York City, for example, there was more or less variation in the broken stone and screenings from day to day, and the inspectors were given authority to slightly vary the relative proportions of these two materials, always keeping the proportion of cement to total aggregate at 1:7, so as to give a mix which worked just right in place.

I will not go further into the methods of making these tests, because I do not wish to take too much of your time, but shall be very glad to answer questions in regard to them. Materials cannot be satisfactorily mixed dry by trial with ordinary apparatus and thus proportioned, because there is so great separation of the coarse and fine particles. Then, too, the addition of the water changes the relations, since a fine sand requires more water to produce the same consistency than a coarse sand, and consequently makes a larger bulk of mortar. Therefore, for the trial mixtures all of the ingredients must be used, including the cement and the water, as well as the aggregates.

The methods are very useful not only for determining the proportions of two materials but for comparing the value of different aggregates, and also selecting proportions where the aggregate is separated into three or more parts. I have just completed a series of tests for a client in which we found that by changing and grading the sizes of the particles, we could obtain a strength two and a half times as great with the same proportions of cement, while, on the other hand, we could maintain equal strength with 40 per cent. less cement. In connection with such combinations, the use of mechanical analysis diagrams and curves very greatly facilitates matters, and in many cases the correct proportions can be directly predicated in advance if the mechanical analysis curves, for the different materials are plotted from the sieve tests and combined. Mechanical analysis methods are eminently scientific and should be destined to greatly increased use both alone and as an auxiliary to other methods of testing.

From these somewhat general observations and from the results of tests which cannot be presented this evening, we may offer the following suggestions as guides to proportioning:

(1) The size of the largest stone in the aggregate should be as great as is consistent with proper placing of the concrete.

(2) If size of stone is small, a richer mixture must be used; thus 1:3:6 is a fairly rich mix with 2-in. stone, but a lean mix with ½-in. stone.

(3) If sand is fine, a smaller quantity may be used in proportion to the stone.

(4) For concrete a sand with too large a percentage of very coarse grains may be detrimental because they will not fit into the voids of the coarse aggregate.

(5) If the broken stone or gravel contains fine stuff, a smaller proportion of sand must be used.

(6) Better proportions are obtained in practice by screening the sand or dust from the coarse material and remixing in required proportions than by using the run of the bank or the run of the crusher.

(7) If the mortar in concrete is rich, say, up to 1:2½, sand should be coarse, with comparatively few fine grains. A lean mortar, on the other hand, is improved not only in strength but in smoothness of working, by using a sand containing dirt or dust.

(8) If fine sand must be used, the proportions must be richer than for coarse sand, because a fine sand makes a mortar of lower density.

A very important point still in question is with reference to the use of fine sand for water-tight work. A few permeability tests which I have made recently indicate that a slight excess of fine grains in the sand is often beneficial for concrete designed for water-tight work. For example, I greatly increased the water-tightness of a 1:3:6 concrete made with ordinary coarse bank sand of a quality to produce a strong mortar, by substituting for one-sixth part of the sand an equal weight of very fine bank sand. This fine sand decreased both density and strength and yet increased the water-tightness. A further increase in fine sand did not appreciably affect the water-tightness at an early age, but on longer time tests the specimen with the small addition of fine sand was much superior to those with a larger quantity of fine grains. In a 1:2:4 concrete made with coarse bank sand, an addition of fine sand did not improve it, evidently because there was a sufficient excess of cement to render more fine sand unnecessary.

## DISCUSSION.

Mr. William Parker. — The question of what to write in specifications concerning the proportioning of concrete is an important one and will continue to be so until all are converted to the cost-plus-a-fixed-sum method of contracting work, and even then some written instructions will be needed for work which is being done at points at a distance from the headquarters of the engineer or architect.

As indicated in the paper of the evening, much depends upon the character of the sand. The old specification which called for sand to be " clean, coarse and sharp " is now generally considered obsolete for lean concretes.

We learn from Mr. Thompson's paper, from his book (Taylor and Thompson: "Concrete, Plain and Reinforced ") and many other sources, that, within certain limits, dirt is beneficial rather than injurious to lean mortars such as are used in the concretes forming the greater bulk of our work.

We also learn that the next term used in the old specification, " coarse," should not stand as it is without qualification, especially for lean mortars. The words " clean and coarse " together have led to a tendency, on the part of those whose business it is to furnish sand, to deliver what should really be called a clean, fine gravel, with almost no fine material in it, and Mr. Thompson tells us that " coarse grains will not fit into the voids of the coarse aggregate." On the other hand, it has been the speaker's experience that a sand which is nearly all of good quality, but fine grains, although it will make a good looking, dense concrete with all parts of the stones well coated with mortar, causes the concrete to be slow setting, which is a very important matter where forms are being used repeatedly, and it is therefore desirable to remove them as quickly as possible.

The third term of the old specification, " sharp," it is now conceded, means but little, either practically or theoretically, although it is the speaker's opinion that the word " angular " might be substituted for it if the work is of a very particular nature.

In order that a contractor may know, when he is making up his bid, what the engineer will require as to the character of sand he is to furnish, something must be said in the specifications concerning it. The requirements of the specifications will also be a guide to the inspector on the work.

For lean concrete we have seen that the old requirement is more exacting than necessary in some respects, while for rich mortars for granolithic work or for structures which are to be watertight, the contractor will be required to make a more careful selection than for ordinary work, attended, in most cases, with additional expense.

The following specifications for sand for lean concrete are quoted from specifications written by the speaker for work done the past year and for some of the contracts which are to be executed the coming season:

"Sand for concrete shall be free from organic matter and shall contain but a small per cent. (not more than 7 per cent.), if any, of clay, subsoil or similar material. The sizes shall be, preferably, a mixture of coarse and fine, but no batch of concrete shall be mixed with wholly fine sand; that is, sand so fine that, after having the coarse parts screened out of a sample by the use of a No. 12 sieve, more than 50 per cent. will pass through a No. 50 sieve."

"No sand which comes out of the banks in cakes or lumps (dead sand) will be allowed in the work."

"Sand for concrete taken directly from the banks need not be screened if it does not contain more than 10 per cent. of pebbles which will be retained on a ¼-in. screen, and if the said pebbles are no greater than the maximum size specified for the different classes of work."

"The material which has passed through the ½-in. screens used in obtaining pebbles from coarse gravel shall not be used for sand for concrete without the addition of fine sand from other sources, so that it will be a proper mixture for filling the voids in pebbles or broken stone."

"Sand for facing and top-finish mortar shall be screened and perfectly clean and of medium size (somewhat coarser than brick mason's sand)."

It cannot be said that these specifications are altogether the result of experience, as, for instance, there has been so far but little, if any, occasion to consider the matter of cleanliness, as it has been so easy to get clean sand. The 7 per cent. mentioned as the allowable amount of clay, etc., is given simply to convey the idea to the contractor and inspector that a sand containing quite an appreciable amount of so-called dirt will not be rejected. Although it is now well known that a much larger percentage, even up to 20, is sometimes admissible, it does not seem wise to use any such figure in specifications for

contract work where but little opportunity will be afforded for careful watching or experimental work. The 50 per cent. in the last part of the first paragraph quoted had better be changed to 30 per cent., and this has been done in later specifications.

Specifications covering the matter of sand for artificial stone platforms are quoted as follows:

"The 1-in. thick layer of platform and 1-in. thick outer layer of curbing shall be composed of one (1) part Portland cement and one and one-half ($1\frac{1}{2}$) parts coarse sand, of the same character as the sample at the engineer's office at Boston and Springfield."

The sample referred to is clean sand, varying in size from little coarser than that which might be called dust to pea size grains. It is also angular. At times it has been necessary to do double screening to get what was required, and a very few times it has been necessary to do some washing.

Crusher dust has been substituted for the specially selected sand for the finish of artificial stone platforms with good results, but the surface is not quite so satisfactory in appearance.

In the paper of the evening the suggestion is made that "Better proportions are obtained in practice by screening the sand or dust from the coarse material and remixing in required proportions than by using the run of the bank or the run of the crusher."

In specifications for a concrete drain the speaker has called for broken stone free from dust and for a certain proportion of dust to be used with sand in making the mortar for the concrete, but for lean concrete the dust has been included with the run of crusher, the specifications being as follows:

"Broken stone for concrete shall be hard and sound, trap-rock, granite or other hard stone of a quality satisfactory to the engineer, free from dirt or dust other than that caused by the crushing of the stone itself."

"The broken stone for all work shall be the entire product of the crusher, including dust, up to and including the size which has passed through the crusher screen having a diameter of about two (2) inches."

"It is intended that the percentage of voids in the broken stone, including dust, shall be about 35 per cent. of the entire mass when moderately packed into place in the gaging-box mentioned below."

"The contractor is to provide and maintain in good order a watertight box which will contain ten (10) cubic feet, for the

purpose of determining, approximately, by experiment, the amount of voids."

"If the proportion of voids exceeds that specified, proper adjustments are to be made by the use of additional sand as directed by the engineer. An excess of dust over that necessary to reduce the voids to the amount specified shall be corrected by a reduction in the amount of sand used."

This method of including dust has been specified for several different jobs, amounting in all to about 40 000 cu. yds. of concrete, and has proved very satisfactory. For the work just referred to nearly all stone came in cars and was Westfield trap rock. The coarse stone is first run into the car, then the next grade and lastly the finest grade which includes the dust. The plant is so arranged that this can be done with little trouble, and other plants visited by the speaker could deliver in the same way almost as easily. The result is that each car has a very close approximation to the proper amount of coarse and fine material, for the man at the valves can estimate quite closely how much of each kind of stone to let out of each bin after a little experience. It is also practical with but little, if any, additional expense, to so conduct the work of shoveling out of the car into buckets or barrows that a fairly uniform mixture is maintained. Even when the whole mass is unloaded on to the ground, there is but little trouble maintaining a uniform mixture. In this way separate cars of coarse and fine material are not required, which is a matter of considerable importance in most cases on railroad work. The entire product of the crusher, in most cases at least, will be taken away at once, and is therefore generally a good arrangement for the operator of the plant.

The finest grade screened out to any extent at the crusher referred to was that which passed through a ⅝-in. round mesh thick manganese steel screen. A sample of this taken from a car delivered on our work was screened with the following results:

Volume of Sample, as Taken from Top Layer in Car, 28.87 cu. in.

| | | | | | | |
|---|---|---|---|---|---|---|
| | Retained on a | No. | 12 | sieve, | 17.14 | cubic inches. |
| Remainder | ,, | ,, | 20 | ,, | 4.51 | ,, |
| ,, | ,, | ,, | 30 | ,, | 3.16 | ,, |
| ,, | ,, | ,, | 50 | ,, | 3.14 | ,, |
| ,, | ,, | ,, | 100 | ,, | 4.06 | ,, |
| ,, | passing through | No. | 100 | ,, | 2.71 | ,, |

Of course the sum of the separate parts (34.72) exceeds the original 28.87. The experiment simply shows that there is a large portion of the fine material which is larger than ordinary sand grains, and also that there is only a small portion that is extremely fine.

With the kind of stone mixture just referred to we have specified $1:3:7\frac{1}{2}$ concrete for abutment foundations, engine pit walls in roundhouses and machine foundations. A machine foundation which it was necessary to remove, in part, was found to be without voids and of great strength, at least so far as its ability to resist being removed was concerned. $1:2\frac{1}{2}:6$ concrete is specified for abutment and similar work.

The amount of sand, 3 parts and $2\frac{1}{2}$ parts, is made comparatively small, due to the proportion of fine material in the stone that is equivalent to sand, and due to the small proportion of voids in the stone resulting from the graded sizes of stone.

Aside from the matter of expense and ultimate strength, it would seem that the volume of sand to the barrel of cement should be kept as small as possible, consistent with making an easily spreading concrete, for work which is to be laid in forms, on account of the need of removing forms as soon as possible; a rich mortar setting, or at least gaining a given strength, much quicker than a lean mortar.

The suggestions in the paper of the evening will certainly aid in writing specifications which will enable the engineer to know beforehand what kind of concrete he will get and which will enable the contractor to estimate closely what the work will cost when he makes his proposal.

## OBITUARY.

### William Thomas Pierce.

Member of the Boston Society of Civil Engineers.

William Thomas Pierce, who died at 12 Russell Avenue, Watertown, Mass., on February 26, 1906, was born November 12, 1854, at Leominster, Mass. He was one of four sons of John Q. A. and Elizabeth C. Pierce, the others being Charles Q., Henry B. and Myron E.

While still young, his parents moved from Leominster to Watertown, Mass., where he received his education in the public schools.

In 1871, before he was seventeen, he decided to adopt a professional life and entered the office of Ernest W. Bowditch, landscape gardener and engineer, as a student. From the first he was a close observer, a great reader, perhaps somewhat omnivorous in literary taste, and early began the excellent practice of indexing his professional reading.

In 1880, when the Mexican Central Railroad was starting construction, he obtained a position on the engineering force of that corporation, realizing that by going to Mexico he was not only enlarging his professional horizon but was taking advantage of an opportunity to broaden his general experience as well.

He liked railroad location and construction together with its free and outdoor life, but as he did not care about the subtropical climate of Mexico he retained his position only till 1882, going from there to Quebec, Canada, to engage on preliminary and location railroad surveys, staying there and in the immediate neighborhood till 1885, when he returned to Boston and reëntered Mr. Bowditch's office as a first assistant engineer.

At this time he took charge of the sewer systems at Bar Harbor, Waltham and Newburyport, during the building of which he developed many original and valuable methods for sewer construction work and in various ways proved fertile in resources.

In 1893, after starting in practice for himself, he was appointed superintendent of streets at Watertown, Mass., a position that he held until chosen chief engineer of the Metropolitan Park System in 1894, which post he held till obliged to withdraw on account of ill health in 1903; and even after that he continued his interest in the work of the office he had organized, until the end, in February, 1906.

Professionally it may be said of him that he was successful to a marked degree, that he was a good workman who knew how to use his tools to best advantage, and intolerant alike of slovenly or careless work in others.

Upright and honest in his dealings, methodical, persistent, conscientious and resourceful with his work, he was a man who not only had the entire confidence of his employers, but, what is quite as important and less common, the good-will of the laboring men and contractors with whom he came in contact.

That he showed himself a capable executive is proved by the effective organization he built up for the Metropolitan Park engineering office, where, amongst other matters, he was at all times trying to standardize the professional work to the end that all plans, notes and calculations could be easily and quickly referred to.

Though naturally quick and impulsive, his temper was well under control and he was quite as ready to laugh at a joke at his own expense as when some other person was the object; and many is the time when he poked fun at what he referred to as his own stupidity.

In August, 1903, he was practically obliged to withdraw from active work and ever after great care was exercised to avoid over-exertion and consequent valvular exhaustion of the heart, which from the first had been very distressing to him. Even when incapacitated from attending to any work he remained cheerful and uncomplaining. The end came February 26, 1906.

The deceased was a member of American Society of Civil Engineers, Boston Society of Civil Engineers, Middlesex Club, Boston Club, Boston Athletic Association.

In 1883 he married Almira P. Goss, of Salem, Mass., who, with one daughter, survives him.

Ernest W. Bowditch,
Daniel W. Pratt,
*Committee.*

Boston, Mass., May 26, 1906.

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**Casper Teiper.**

Member of the Engineers' Society of Western New York.

On March 8, 1906, entered into rest at his home in the city of Buffalo, Casper Teiper, in the fifty-ninth year of his life.

Mr. Teiper, from the earliest portion of his career, was identified with the iron and steel business, most of the time being engaged in the manufacture of bridges and allied structures, and he witnessed and, indeed, had a prominent part in the development of that important part of the iron and steel industry from its infancy to the present day.

Mr. Teiper was a thorough bridge and structural engineer, his ability in this line being self-acquired, he never having had the advantages of a college education. His business connections for many years with the largest bridge company of Canada threw him into contact with the noted bridge engineers of the country, who placed in his care the fabrication and erection of most of the important bridges on the railroads of the Dominion.

Mr. Teiper was a many-sided man, being also expert in mechanical engineering, which enabled him to design and build successfully all kinds of heavy tools used in the fabrication of bridges. While engineer and superintendent of the Hamilton Bridge and Tool Works, this was a very important part of the business placed in his care. While at Hamilton he built the sheathing for the Port Huron tunnel, and also steel boats of various descriptions, among them being the *Chippewa*, which now plies between Lewiston and Toronto. Such achievements as these show the many-sided character of Mr. Teiper's mind and serve as monuments to the esteem in which his ability was held by men high up in engineering and business life.

Mr. Teiper was an indefatigable worker, never taking vacations, the only respite from business being in traveling on the trains from point to point where business took him. This extreme devotion to his work, however, was the cause of his physical decline, for he became afflicted with a creeping paralysis which nineteen years ago fastened itself upon him and, despite all efforts, gradually became more and more insidious and resulted finally in his death as above noted.

Mr. Teiper was born in Germany, November 13, 1846. Early in life he was brought to this country by his parents and settled in Detroit. When old enough to work, he located in New York City, where he was employed by a firm engaged in the building of marine engines. While there he spent his leisure time in the study of bridge engineering, taking an evening course at the Peter Cooper Institute. From August, 1871, to May, 1876, he was employed as draughtsman in the office of the Kellogg Bridge Company, of Buffalo, N. Y. From May, 1876,

to May, 1877, he was managing partner in the Vulcan Iron Works, of Bay City, Mich. From May, 1877, to September, 1879, he was employed as engineer and superintendent of the Hamilton Bridge Company, of Hamilton, Ont. From October, 1879, to September, 1880, he was engaged in the engineering department of the Keystone Bridge Company, of Pittsburg, Pa. From September, 1880, to April, 1892, he was engaged as engineer and manager of the Hamilton Bridge and Tool Company, of Hamilton, Ont. In April, 1892, he returned to this country and formed a partnership with Mr. Carl Meyer, they styling themselves the Buffalo Bridge and Iron Works. Here he acted as engineer. His disease at this time was severely taxing his strength and he decided to discontinue business, and in August, 1894, he sold his share of the business to Mr. Robert Wilson. He then took a trip abroad in an endeavor to regain his health, but with little result. He returned in the latter part of 1894, found that he could not remain idle and decided to go into business again. He bought a piece of land at Letchworth and Dark streets, Buffalo, and erected upon it the plant of the Buffalo Structural Steel Works, of which he was proprietor until its conversion in February, 1899, into the Buffalo Structural Steel Company, a corporation doing business under the laws of New York state. Mr. Teiper was president of this company from its formation until his death.

During the last four years of his life Mr. Teiper was physically absolutely helpless, yet his mind was alert and keen as ever. Even during this time he attended strictly to business, being to the office an example of unswerving regularity.

To them who knew him best Mr. Teiper presented a remarkable object lesson. His life taught one to be regular and precise in the performance of duty; to be cheerful in the presence of great bodily discomfort; to overcome the greatest obstacles in the attainment of laudable ambitions, and above all, to be honorable and honest in dealing with his fellowman, down to the minutest detail. His wife, Agnes M. Teiper, one daughter and three sons, survive him.

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## Dean Clyde Warren.

Member of the Boston Society of Civil Engineers.

Mr. Warren was the eldest of three brothers. He was born in the town of Stowe, Vt., May 31, 1874; attended the

district school near his father's farm; graduated from the Stowe High School, and took a college preparatory course of two years, 1890 and 1891, at the People's Academy, Morrisville, Vt.

It was his ambition to enter the Military Academy at West Point, and doubtless he could have won an appointment as he stood second in a class of over a hundred at the Morrisville Academy. His parents, however, did not wish him to go to West Point and as a compromise he was sent to the Scientific Military School, Norwich University, at Northfield, Vt. He entered in the class of 1896, but completed the course in three years, graduating in 1895 at the head of his class.

His first work after leaving college was upon some preliminary surveys for the Mt. Mansfield Electric Railroad, running from Waterbury to Stowe, Vt.

He was employed by the firm of French & Bryant, Brookline, Mass., a few months during the fall of 1895, and again in 1896 and 1899. His work with them consisted of surveys, the construction of roads, sewers and water works.

During the winter of 1895-96 he was connected with the City Engineer's Office, Somerville, Mass., and engaged in the general work of the office.

In the spring of 1896, together with a classmate, he went to Colorado and was for a time in the office of Davis & Byler, United States Deputy Mineral Surveyors, at Victor, in the Cripple Creek gold mining region. His work there consisted in running out claims and preparing plans and descriptions for United States patents.

The spring of 1896 saw the end of the "boom" in the Cripple Creek country and, as a consequence, a less demand for the services of engineers. Mr. Warren and his companion thought it the wisest plan to return East while they yet had the means rather than seek employment there under unfavorable conditions.

After working two months in the office of French & Bryant, at Brookline, Mass., he entered the office of the City Engineer of Cambridge, Mass., in July, 1896, and remained until November, 1898. He was engaged in Cambridge mostly on the survey and construction of the River Parkway, about four miles in length, along the north shore of the Charles. The work consisted of surveys and location, the supervision of construction of sea-walls and bulkheads, dredging and filling, the building of roadways and the creation of much agreeable landscape where there had been only salt marsh and mud flats.

During the winter of 1898–99 he was engaged as assistant engineer on the construction of the Rutland Canadian Railroad in Northern Vermont, on a section including the crossing of Lake Champlain at its northerly end.

Mr. Warren again worked in Brookline a short time in the spring of 1899. In June he entered the employ of the Metropolitan Sewerage Works, where, as assistant engineer, he was in charge of important construction work on the North Metropolitan system and on the High Level Sewer, including tunnel work and river crossings.

He was in the office of Olmsted Brothers, landscape architects, in 1904, and from June 1 to September 1, 1904, in the employ of the Massachusetts Highway Commission, most of the time in the Boston office, but for a short time as resident engineer of a section of road in Burlington, Mass.

On September 1, 1904, he took a position as assistant engineer on the rapid transit railroads of New York City, and was given immediate charge of the construction work in the New York heading of the tunnel under the East River from the Battery to Brooklyn.

He was employed constantly after leaving college, with the exception of a few weeks during the winter of 1898–99, but had never been absent from his work a day on account of sickness.

Mr. Warren had a weak heart, and early in March, 1905, when his physician forbade him to go again under air pressure, he felt that he was not doing his duty, and was annoyed greatly at not being able to go into the tunnel, though he kept on with the outside work.

The immediate cause of his death was due to blood poisoning, developing from a carbuncle. He left his office on Monday, July 3, complaining of a slight cold, but was out of doors again on Wednesday. The end came very suddenly and without warning and he passed away at midday, Thursday, July 6, 1905, in Brooklyn, N. Y. He was buried at Stowe, Vt.

Mr. Warren was married in Cambridge, Mass., September 27, 1900, to Maude Ella Mills, who survives him. He left no children.

He became a member of the Boston Society of Civil Engineers, March 18, 1903. All who came in contact with him professionally found him agreeable, energetic and capable; he had both patience and good judgment in an unusual degree, was conscientious and quiet in the performance of his duties

and commanded the confidence and esteem of those who were in any way associated with him. He made excellent use of his engineering training and was unusually careful and skillful in his work, which he did in a thorough and efficient manner. He was a constant reader of current engineering literature and accumulated a considerable engineering library. Of his future success as an engineer there was no doubt. He was a kind and loving husband, a loyal friend, always cheerful and ever ready to assist others in time of need.

J. Albert Holmes,
DeWitt C. Webb,
*Committee.*

# ASSOCIATION OF ENGINEERING SOCIETIES.

ARTICLES OF ASSOCIATION ADOPTED DECEMBER 4, 1880.

FOR the purpose of securing the benefits of closer union and the advancement of mutual interests, the engineering societies and clubs hereunto subscribing have agreed to the following Articles of Association.

## ARTICLE I.

### NAME AND OBJECT.

The name of this Association shall be the "Association of Engineering Societies." Its primary object shall be to secure a joint publication of the papers and transactions of the participating societies.

## ARTICLE II.

### ORGANIZATION.

SECTION 1. The affairs of the Association shall be conducted by a Board of Managers under such rules and by-laws as they may determine, subject to the specific conditions of these articles. The Board shall consist of one representative from each society of one hundred members or less, with one additional representative from each additional one hundred members, or fraction thereof over fifty. The members of the Board shall be appointed as each society shall decide, and shall hold office until their successors are chosen.

SECT. 2. The officers of the Board shall be a Chairman and Secretary, the latter of whom may or may not be himself a member of the Board.

## ARTICLE III.

### DUTIES OF OFFICERS.

SECTION 1. The Chairman, in addition to his ordinary duties, shall countersign all bills and vouchers before payment and present an annual report of the transactions of the Board; which report, together with a synopsis of the other general transactions of the Board of interest to members, shall be published in the JOURNAL OF THE ASSOCIATION.

SECT. 2. The Secretary shall be the active business agent of the Board and shall be appointed and removed at its pleasure. He shall receive a compensation for his services to be fixed from time to time by a two-thirds vote. He shall receive and take care of all manuscript copy and prepare it for the press, and attend to the forwarding of proof-sheets and the proper printing and mailing of the publications. He shall have power, with the approval of any one member of the Board, to return manuscript to the author for correction if in bad condition, illegible or otherwise conspicuously deficient or unfit for publication. He shall certify to the correctness of all bills before transmitting them to the Chairman for countersignature. He shall receive all fees and moneys paid to the Association and hold the same under such rules as the Board shall prescribe.

## ARTICLE IV.

### PUBLICATIONS.

SECTION 1. Each society shall decide for itself what papers and transactions of its own it desires to have published and shall forward the same to the Secretary.

SECT. 2. Each society shall notify the Secretary of the minimum number of copies of the joint publications which it desires to receive, and shall furnish a mailing-list for the same from time to time. Copies ordered by any society may be used as it shall see fit. Payments by each society shall, in general, be in proportion to the number of copies ordered, subject to such modification of the same as the Board of Managers may decide by a two-thirds vote to be more equitable. Assessments shall be quarterly in advance, or otherwise, as directed by the Board.

SECT. 3. The publications of the Association shall be open to public subscription and sale, and advertisements of an appropriate character shall be received under regulations to be fixed by the Board.

SECT. 4. The Board shall have authority to print with the joint publications such abstracts and translations from scientific and professional journals and society transactions as may be deemed of general interest and value.

## ARTICLE V.

### CONDITIONS OF PARTICIPATION.

SECTION 1. Any society of engineers may become a member of this Association by a majority vote of the Board of Managers, upon payment to the Secretary of an entrance fee of fifty cents for each active member, and certifying that these Articles of Association have been duly accepted by it. Other technical organizations may be admitted by a two-thirds vote of the Board, and payment and subscription as above.

SECT. 2. Any society may withdraw from this Association at the end of any fiscal year by giving three months' notice of such intention, and shall then be entitled to its fair porportion of any surplus in the treasury, or be responsible for its fair proportion of any deficit.

SECT. 3. Any society may, at the pleasure of the Board, be excluded from this Association for non-payment of dues after thirty days' notice from the Secretary that such payment is due.

## ARTICLE VI.

### AMENDMENTS.

These articles may be amended by a majority vote of the Board of Managers, and subsequent approval by two thirds of the participating societies.

## ARTICLE VII.

### TIME OF GOING INTO EFFECT.

These articles shall go into effect whenever they shall have been ratified by three societies, and members of the Board of Managers appointed. The Board shall then proceed to organize, and the entrance fee of fifty cents per member shall then become payable.

# RULES OF THE BOARD OF MANAGERS OF THE ASSOCIATION OF ENGINEERING SOCIETIES, ADOPTED MARCH 1, 1905.

## SOCIETIES.

### Assessments.

1. Assessment bills shall be rendered to the societies quarterly after the mailing of the Journals for March, June, September and December.

2. Each society shall be assessed in proportion to the number of names upon its mailing list at the time when the assessment is made.

3. Each society shall be entitled to receive, gratis, five copies of each issue of the Journal for each of its representatives on the Board of Managers of the Association.

### Delinquent Societies.

4. Any society which shall remain indebted to the Association for a sum exceeding two dollars per member for more than ninety days after mailing of notice by the Secretary, shall be suspended from the privileges of the Association until the cause be removed, provided that this rule shall not apply to indebtedness on account of advertisements secured by the society for the Journal.

### Government.

5. A meeting of the Board of Managers may be called by the Chairman at any time, and shall be called by the Chairman or Secretary upon the written request of any three members of the Board, and such call shall give not less than three weeks' notice of said meeting.

6. At any meeting of the Board of Managers, duly called as provided in Rule 5, one fourth of the whole number of members (including the Chairman) shall constitute a quorum, provided that not less than three of the constituent societies be represented at such meeting.

7. Motions for letter ballot shall be made and seconded and then forwarded by the Chairman to each member of the Board for discussion.

8. All letter ballots shall close four weeks after the date of mailing call, by the Chairman, for vote.

9. Rules of the Board of Managers may be amended at any time by a majority vote of the Board, as ascertained by letter ballot.

### Officers.

10. The term of office of the Chairman and that of the Secretary shall be two (2) years, and shall begin on January 1 of the even years, but they shall remain in office till their successors are chosen.

11. The election of officers shall occur at any time at a called meeting of the Board, or by letter ballot between October 1 and December 1 of the odd years.

12. If the election is by letter ballot, the Chairman shall, through the Secretary, give notice of such election prior to October 10 of each odd year, and shall also give notice, at the same time, of the appointment of two tellers in one city, members but not officers of the Board, to whom

the votes shall be mailed. These tellers shall open the ballots on November 1, and report the result to the Chairman of the Board. If no one has received a majority of the votes cast for either office, the Chairman shall order a new ballot, similar to the first, but limiting the names voted for to the two receiving the highest numbers of votes for that office on the first ballot. The tellers shall open the second ballot on December 1, and report as before. The Chairman shall then announce the result of the ballot to all the members, and the new officers shall act from the beginning of the following calendar year. In the event of the second ballot resulting in a tie, the Chairman shall select between the two candidates by lot.

13. Vacancies in the offices of the Board may be filled at any time, either by a meeting of the Board or by letter ballot. In case of a vacancy occurring, the remaining officer shall discharge the duties of both till the vacancy is duly filled.

14. The Secretary shall receive a salary of nine hundred dollars ($900) per annum.

## ACCOUNTS.

### Audit.

15. Prior to the close of each odd year, the Chairman shall appoint from the members of the Board of Managers, two auditors to examine and report upon the accounts of the Secretary.

## JOURNAL.

### Contents.

16. The matter published in the Journal shall be restricted to:

(*A*) *Monthly.*

1. Papers submitted by the societies for publication, including presidential addresses and memoirs of deceased members.
2. Proceedings of meetings of the societies.
3. Lists of officers of the societies.
4. List of members of Board of Managers.
5. Advertisements.

(*B*) *Annually.*

1. Annual report of Chairman and of Secretary of Board of Managers.
2. Articles of Association, Rules of Board and rulings of Chairman.

(*C*) *Biennially.*

Report of Auditors.

### Conduct.

17. Arrangements with printers and illustrators shall be made by the Secretary, subject to the approval of the Board of Managers.

18. The arrangement of matter, the selection and manner of reproducing illustrations and all other matters relating to typography, shall be decided by the Secretary with the approval of the Chairman.

19. The Secretary shall insert in each issue of the Journal the following: Editors reprinting articles from this Journal are requested to credit the author, the Journal of the Association and the society before which such articles were read.

20. Authors of papers appearing in the JOURNAL shall have appended to their names only the words, "Member of................Society."

REPRINTS.

21. Reprints of papers appearing in the JOURNAL shall be made, when requested, for the account of the societies submitting the papers for publication.

22. Each author shall be entitled to receive gratis 50 reprints of his paper, with its discussion and illustrations, on condition that application for such reprints is made by the author, through the secretary of the society presenting the paper for publication, previous to the printing of the paper for the JOURNAL.

23. The rates of charges to the societies for other reprints shall be adjusted by the Chairman and Secretary.

ILLUSTRATIONS.

24. Cuts, published with linear scales, shall bear metric scales, unless objection is made by the authors.

ADVERTISEMENTS.

25. The procuring and selection of advertisements, including the fixing of rate of commissions, shall be subject to the control of the Chairman and Secretary.

26. Advertisements procured for the JOURNAL by the societies composing the Association shall be charged to those societies, less 90 per cent commission.

SUBSCRIPTIONS.

27. The rate of subscription to the JOURNAL shall be $3.00 per annum.

28. Dealers shall be allowed on subscriptions a discount of 50 cents per annum.

29. Educational and charitable institutions may be furnished with the JOURNAL at $1.50 per annum, subject to the approval of the Chairman and Secretary.

EXCHANGES.

30. Exchanges with other periodicals may be made subject to the approval of the Chairman and Secretary.

SALES AND GRATIS COPIES.

31. The price of single copies of the JOURNAL shall be 30 cents, less a discount of 5 cents to dealers.

32. Members of the societies belonging to the Association shall be entitled to receive copies of the JOURNAL at 20 cents each. This rule is subject to amendment by the Chairman and Secretary in the case of scarce or surplus numbers, or of sets of back numbers.

33. The Secretary is authorized to furnish to the author of any paper to whom reprints are not given, and to each of those taking prominent part in the discussion, five gratis copies of the JOURNAL containing such paper, and, at 15 cents each, additional copies of the issue of the JOURNAL containing such paper, provided due notice be given in advance, stating the number of such extra copies wanted.

## FINAL CONTROL BY BOARD.

34. The exercise of any discretions herein delegated to the Chairman and Secretary shall be subject to the final control of the Board of Managers.

## ANNUAL REPORT OF THE CHAIRMAN OF THE BOARD OF MANAGERS.

BOSTON, June 23, 1906.

*Gentlemen,*— In presenting my report for the year ending December 31, 1905, with the report of the Secretary, I desire to thank the members of the Board for the confidence expressed and honor conferred by my reëlection as your chairman for a further term.

The interesting facts regarding the publication of the JOURNAL, which is the primary purpose of the Association, are fully stated in detail in the Secretary's report.

The number of societies belonging to the Association remains the same as in 1904, with a net increase in membership, as shown by the mailing list of the JOURNAL, of 76. The net assets of the Association remain substantially the same as at the close of the previous year.

Although the aggregate membership of the several societies is more than 50 per cent. greater than in 1894, the number of pages of papers published during the past year was 16 per cent. less than in the earlier year. This may indicate that times are so prosperous that the members of the engineering profession have little time to devote to literary work, but the result is to be deplored, and it is hoped that a different statement can be made at the close of the coming year.

The reduction in the number of papers presented for publication, and the fact that the number of illustrations required was also smaller, made possible a material reduction in the cost of the JOURNAL. There has, however, been so large an increase in the cost of printing during the past two years that the annual assessment for the JOURNAL is not likely to fall below $2.50 per annum.

Several important matters have been considered by the Board during the year, although no meeting was held, the business having all been conducted by correspondence.

The question of codifying and revising the rules of the Board, which had been under consideration during the greater part of the year 1904, was finally decided on March 1 by the adoption of the rules appended to this report.

The position of secretary, made vacant by the resignation of Mr. John C. Trautwine, Jr., who for many years had so ably

managed the business affairs of the Association, was filled in March by the election of Frederick Brooks, of Boston. Mr. Trautwine's resignation was presented to take effect on December 31, 1904, but he very kindly took charge of the publication of the first three numbers of the JOURNAL, and in April the publication office was removed from Philadelphia to Boston.

In closing, I ask for the same hearty coöperation which has been given during the past two years, in order that the Association may continue to grow and be of increased value to the engineering profession.

Respectfully submitted,

DEXTER BRACKETT,
*Chairman.*

## ANNUAL REPORT OF THE SECRETARY OF THE BOARD OF MANAGERS.

31 Milk Street, Boston, June, 1906.

*Dexter Brackett, Chairman Board of Managers:*

Dear Sir, — I submit as the chief feature of the report of the Secretary for the year 1905, during the greater part of which I was Secretary, the following nine statements in tabular form, A to J, corresponding to the forms used in the 1904 report of my predecessor. I add a few comments with regard to changes during the year, etc.

The expense for postage has been increased by the transfer of the place of publication to Boston, inasmuch as the regulations of the Post Office Department require payment at the rate of a cent for two ounces upon Journals delivered by carrier within the postal district where the Journal is published. This includes a very large number in the case of the Boston Postal District, but included only a small number in the case of the Philadelphia Postal District. The Journals going outside of the postal district where they are published have the benefit of the pound rate as second-class matter. This has made a difference estimated at about seven dollars per month in the expense of mailing the Journal.

The theory of the publication of the Journal appears to have been that it was a record, or minutes of proceedings, for a month, and was to be published during the following month. This practice, being at variance with the common custom of publishing periodicals as early as the date which they bear, has caused annoyance in several ways; and it is thought preferable to have the Journal of any month published in that month. The present Secretary has fallen considerably behind even the above-mentioned theoretical program. Nevertheless, he intends to bring the publication up to date in accordance with the usual custom.

Exchanges are considered important because of their affording to other periodicals the opportunity of giving credit to the Journal among their readers. On the other hand, those other periodicals when sent to the Secretary have not been put to the corresponding use, as the Journal publishes nothing from other periodicals. Instead of having them sent to the Secretary of the Association, it appeared better to have the other periodicals sent directly to such of the societies as desired them. Though this was not fully carried out until after the expiration of the year 1905, the result is that a list of the exchanges was sent to the secretaries of the local societies accompanied by a letter asking what price each Society would be willing to pay to the Association for any desired periodicals, also what periodicals it would like to receive if it did not have to pay for them. After comparing the few replies that were received, a few of the periodicals were assigned to the highest bidders; and a great many for which no offers to pay had been made were assigned to societies which expressed willingness to receive them gratis. These periodicals have accordingly been requested to change their address from the office of the Secretary of the Association to that of a local society, and they have in many cases complied with this request. The remaining periodicals upon

our exchange list have generally been notified that we do not have use for copies from them although we shall be pleased to continue sending them the JOURNAL.

Incidentally to the removal of the place of publication of the JOURNAL a great reduction has been made of the stock on hand of back numbers of the JOURNAL. It was stated in the Secretary's report for 1904 that about 43 000 numbers were on hand. There are scarcely any copies sold of JOURNALS more than five or six years old, though there is a considerable sale of recent numbers to supply lost copies, etc. Accordingly, a large amount of the accumulated stock was sold as old paper, and there was removed to Boston only a limited number of copies of each number of the JOURNALS of past years (about 12 000 in all), so that the expense for transportation and storage was not nearly as great as would have been involved in an attempt to remove the whole 43 000.

Respectfully yours,

FRED. BROOKS.

## APPENDIX A.

### STATEMENT OF RECEIPTS AND EXPENDITURES DURING 1905.

CASH, 1905.

*Dr.*

| | |
|---|---|
| To Cash Balance, January 1, 1905 | $457.93 |
| ,, Engineers' Club of St. Louis | 648.44 |
| ,, Civil Engineers' Club of Cleveland | 766.98 |
| ,, Boston Society of Civil Engineers | 1 550.44 |
| ,, Engineers' Club of Minneapolis | 85.41 |
| ,, Civil Engineers' Society of St. Paul | 53.01 |
| ,, Montana Society of Engineers | 331.50 |
| ,, Technical Society of the Pacific Coast | 644.77 |
| ,, Detroit Engineering Society | 568.62 |
| ,, Engineers' Society of Western New York | 142.50 |
| ,, Louisiana Engineering Society | 285.64 |
| ,, Toledo Society of Engineers | 174.78 |
| ,, Subscriptions | 749.57 |
| ,, Advertisements | 201.00 |
| ,, Sales of JOURNAL | 111.90 |
| ,, ,, ,, Reprints | 2.50 |
| ,, ,, ,, Descriptive Index | 22.50 |
| ,, ,, ,, Sundries | 32.75 |
| ,, Interest on deposits | 26.64 |
| | $6 856.88 |

*Cr.*

| | |
|---|---|
| By Printing | $3 954.97 |
| ,, Illustrations | 415.64 |
| ,, Secretary's salary | 250.00 |
| ,, Journal index | 51.00 |
| ,, Stationery | 36.89 |
| ,, Postage | 384.30 |
| ,, Telegrams and telephone | 42.04 |
| ,, Express charges | 3.20 |
| ,, Sundry expenses | 75.23 |
| ,, Cash balance, December 31, 1905 | 1 642.71 |
| | $6 856.88 |

## APPENDIX B.

### Expenses and Earnings for 1905.
(" Profit and Loss.")

EXPENSES.

| | | |
|---|---|---|
| Printing and binding | $2 416.58 | |
| Illustrations | 1 060.14 | |
| Mailing | 334.82 | |
| Secretary's salary | 250.00 | |
| Advertising expenses | 1.00 | |
| Journal Index | 51.00 | |
| Stationery | 87.39 | |
| Postage | 45.74 | |
| Telegrams (and telephone) | 42.94 | |
| Express charges | 5.55 | |
| Sundry expenses (some packing and storing Journals) | 148.12 | |
| Commission on subscriptions | 38.65 | |
| ,, ,, society advertisements | 539.70 | |
| ,, ,, sales of Journal | 3.90 | |
| Sales of reprints | 168.86 | |
| | | $5 194.39 |

EARNINGS.

| | | |
|---|---|---|
| Excess payment by Engineers' Club of St. Louis on second assessment | $0.02 | |
| Assessments | 4 271.27 | |
| Subscriptions | 673.70 | |
| Association advertisements | 82.00 | |
| Society advertisements | 599.67 | |
| Sales of Journals | 111.53 | |
| ,, ,, Descriptive Index | 17.50 | |
| ,, ,, exchanges | 9.25 | |
| ,, ,, sundries | 8.50 | |
| Interest | 26.64 | |
| | | 5 800.08 |
| Excess of earnings over expenses | | $605.69 |

Accounts with Societies include, besides their subscriptions to Journal, some charges for advertisements, reprints, exchanges, etc. Printers' bills include, besides the Journal, some charges for reprints, illustrations, stationery, freight, etc. The figures for the minor items of Receipts and Expenditures and Assets and Liabilities vary accordingly from those of Expenses and Earnings. The item of mailing Journal consists largely of postage.

## APPENDIX C.

### Balance Sheet, December 31, 1905.

ASSETS.

| | | | |
|---|---|---|---|
| Cash | | $1 642.71 | |
| Receivable from Societies: | | | |
| Engineers' Club of St. Louis | $133.08 | | |
| Civil Engineers' Club of Cleveland | 7.00 | | |
| Boston Society of Civil Engineers | 34.90 | | |
| Engineers' Club of Minneapolis | 302.38 | | |
| Montana Society of Engineers | 66.25 | | |
| Technical Society Pacific Coast | 1.50 | | |
| Engineers' Society Western N. Y. | 67.50 | | |
| | | 612.61 | |
| Subscribers | | 98.63 | |
| Purchasers of Journal | | 9.50 | |
| Advertisers | | 101.66 | |
| Furnishers (deposited with Postmaster) | | 4.80 | |
| Stock of Journal * | $390.80 | | |
| Stock of Descriptive Index | 175.00 | | |
| | | 565.80 | |
| | | | $3 035.71 |

LIABILITIES.

| | | |
|---|---|---|
| Secretary's salary, eight months | $600.00 | |
| Printers | 146.87 | |
| | | 746.87 |
| Net assets, December 30, 1905 | | $2 288.84 |

* Figures of Stock of Journal differ from what was given for the previous year only by the sum for which part was sold as old paper, it being assumed that any other decrease and increase balanced each other. There was decrease by other sales of old copies and increase by the printing of surplus copies of the 1905 Journals.

# APPENDIX D.

## DETAILED STATEMENT OF GROSS COST OF JOURNAL DURING 1905, BY MONTHS.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Composition. | Paper, Presswork and Binding. | Wrapping, etc. | Postage. | Sum of 1, 2, 3 and 4. | Illustrations. | Manufacture. Sum of 1, 2 and 6. | Wrappers. | Sec'y's Salary. | Sundries. | Sum of 5, 6, 8 and 9. | No. of Pages.† | Total Gross Cost per Page.‡ | No. of Copies Printed. |
| January.... | $96.69 | $107.72 | $7.02 | $10.34 | $221.77 | $47.65 | $252.06 | $4.75 | $50.00 | $19.07 | $324.17 | 64 | $5.07 | 2 500 |
| February... | 84 42 | 151.05 | 6.15 | 12.34 | 253.96 | 214.93 | 450.40 | 4.75 | 50.00 | 19.07 | 523.64 | 72 | 7.27 | 2 500 |
| March...... | 172.70 | 220.22 | 7.77 | 19.16 | 419.85 | 178.53 | 571.45 | 4.75 | 75.00 | 19.07 | 678.13 | 138 | 4.91 | 2 500 |
| April....... | 177.38 | 127.05 | 46.20 | 12.34 | 362.97 | 3.70 | 308.13 | * | 75.00 | 19.07 | 441.67 | 104 | 4.25 | 2 500 |
| May........ | 81.10 | 99.40 | 12.46 | 21.67 | 214.63 | 354.53 | 535.03 | | 75.00 | 19.07 | 644.16 | 78 | 7.31 | 2 500 |
| June....... | 131.40 | 138.60 | 10.42 | 20.31 | 300.73 | 123.30 | 393.30 | | 75.00 | 19.07 | 499.03 | 112 | 4.46 | 2 500 |
| July........ | 91.15 | 99.00 | 9.67 | 16.82 | 216.64 | 38.90 | 229.05 | | 75.00 | 19.07 | 330.54 | 82 | 4.06 | 2 450 |
| August..... | 45.85 | 71.15 | 11.03 | 15.03 | 143.06 | 9.10 | 126.10 | | 75.00 | 19.07 | 227.16 | 54 | 4.34 | 2 500 |
| September.. | 54.53 | 71.15 | 9.81 | 14.71 | 150.20 | 22.79 | 148.47 | | 75.00 | 19.07 | 247.99 | 54 | 4.59 | 2 500 |
| October..... | 29.95 | 59.40 | 8.98 | 14.21 | 112.54 | 50.04 | 139.39 | | 75.00 | 19.07 | 237.58 | 42 | 5.66 | 2 500 |
| November.. | 44.00 | 71.15 | 9.63 | 14.57 | 139.35 | 2.46 | 117.61 | | 75.00 | 19.07 | 216.81 | 54 | 4.25 | 2 500 |
| December... | 105.06 | 95.45 | 9.74 | 16.48 | 226.73 | | 201.51 | | 75.00 | 19.08 | 301.73 | 72 | 4.51 | 2 500 |
| | $1 114.23 | $1 311.34 | $148.88 | $187.98 | $2 762.43 | $1 045.93 | $3 472.50 | $14.25 | $850.00 | $228.85 | $4 672.61 | 926 | $5.06 | 29 950 |

* In subsequent numbers wrappers were included in printers' charge.
† Plus covers.
‡ Exclusive of sundries.

## APPENDIX E.

NET COST OF JOURNAL, 1905.

| | | | |
|---|---|---|---|
| Gross cost, as per Appendix D | | | $4 672.61 |
| Add cost of reprints | | $309.85 | |
| Less sales of reprints | | 140.99 | |
| | | | 168.86 |
| | | | $4 841.47 |
| Deduct earnings, as per Appendix B: | | | |
| From subscriptions | $673.70 | | |
| Less commissions | 38.65 | | |
| | | $635.05 | |
| From sales of JOURNAL | $111.53 | | |
| Less commissions | 3.90 | | |
| | | 107.63 | |
| From sales of Descriptive Index | | 17.50 | |
| ,, ,, ,, exchanges | | 9.25 | |
| ,, ,, ,, sundries | | 8.50 | |
| ,, Association advertisements | | 82.00 | |
| ,, society advertisements | $599.67 | | |
| Less commissions | 539.70 | | |
| | | 59.97 | |
| From interest on deposits | | 26.64 | |
| | | | 946.54 |
| Net cost of JOURNAL, 1905 | | | $3 894.93 |
| Net cost per 100 copies, 1905 | | | $13.00 |
| ,, ,, ,, ,, ,, 1904 | | | 17.72 |
| Decrease, 1905, 26.6 per cent | | | $4.72 |

## APPENDIX F.

[STATEMENT OF MATERIAL IN JOURNAL DURING 1905, BY PAGES

| | Papers. | Proceedings. | Chairman's Report, etc. | Advertisements. | Indexes to Vols. | Totals. | Cuts. | Plates and Full-Page Cuts. |
|---|---|---|---|---|---|---|---|---|
| January | 16 | 0 | 16 | 18 | 0 | 59 | 8 | 2 |
| February | 41 | 8 | 0 | 18 | 0 | 67 | 21 | 0 |
| March | 83 | 31 | 0 | 18 | 0 | 132 | 12 | 18 |
| April | 66 | 16 | 0 | 18 | 0 | 100 | 13 | 0 |
| May | 55 | 1 | 0 | 18 | 0 | 74 | 12 | 22 |
| June | 81 | 1 | 0 | 18 | 7 | 107 | 22 | 2 |
| July | 60 | 0 | 0 | 18 | 0 | 78 | 10 | 6 |
| August | 29 | 5 | 0 | 18 | 0 | 52 | 12 | 0 |
| September | 27 | 7 | 0 | 18 | 0 | 52 | 0 | 1 |
| October | 21 | 1 | 0 | 18 | 0 | 40 | 2 | 5 |
| November | 30 | 3 | 0 | 19 | 0 | 52 | 0 | 1 |
| December | 43 | 3 | 0 | 18 | 5 | 69 | 0 | 1 |
| | 552 | 85 | 16 | 217 | 12 | 882 | 112 | 67 |
| Covers | | | | | | 48 | | |
| Total | | | | | | 930 | | |

## APPENDIX G.

Comparison of the mailing lists of the JOURNAL at the close of 1904 and 1905 respectively:

| | 1904. | 1905. | Increase. | Decrease. |
|---|---|---|---|---|
| Engineers' Club of St. Louis | 209 | 209 | | |
| Civil Engineers' Club of Cleveland | 216 | 254 | 38 | |
| Boston Society of Civil Engineers | 595 | 614 | 19 | |
| Engineers' Club of Minneapolis | 98 | 99 | 1 | |
| Civil Engineers' Society St. Paul | 21 | 23 | 2 | |
| Montana Society of Engineers | 102 | 92 | | 10 |
| Technical Society of the Pacific Coast | 171 | 169 | | 2 |
| Detroit Engineering Society | 139 | 167 | 28 | |
| Engineers' Society of Western New York | 51 | 52 | 1 | |
| Louisiana Engineering Society | 70 | 67 | | 3 |
| Toledo Society of Engineers | 71 | 71 | | |
| In the societies of the Association | 1 743 | 1 817 | 89 | 15 |
| Net increase ........ 74 | | | | |
| Extra copies to societies | 56 | 95 | 39 | |
| Advertisers | 31 | 23 | | 8 |
| Exchanges | 141 | 131 | | 10 |
| Subscribers | 232 | 236 | 4 | |
| Complimentary copies | 1 | 2 | 1 | |
| | 2 204 | 2 304 | 133 | 33 |

# APPENDIX H.

## Comparison of Conditions, 1894 to 1905, Inclusive.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Pages of Papers. | | Gross Cost of Journal.* | | | | | Illustrations. | | | |
| Year. | Number of Societies in Association, Dec 31. | Number of Names on Mail Lists of Societies, Dec. 31. | Subscribers, Dec. 31. | Exchanges, Dec. 31. | Net Earnings from Advertisements. | Total Number of Pages in Journal. | Total. | Per 1 000 Members on Mail List. | Total. | Per Page. | Per Member. | Per Member per 1 000 Pages. | Annual Assessment per Member. | Small Cuts. | Plates and Full-Page Cuts. | Cost. Appendix B. | Net Assets, Dec. 31. Appendix C. |
| 1894 | 8 | 1 174 | 170 | 110 | $671.00 | 1 290 | 653 | 556 | $5 775.59 | $4.48 | $4.92 | $3.81 | $3.00 | 86 | 54 | $651.60 | —$758.91† |
| 1895 | 11 | 1 477 | 215 | 122 | 599.09 | 1 482 | 792 | 536 | 5 911.48 | 3.99 | 4.00 | 2.70 | 3.66 | 116 | 66 | 859.60 | 223.93 |
| 1896 | 9 | 1 106 | 241 | 108 | 763.25 | 856 | 490 | 443 | 3 928.42 | 4.59 | 3.55 | 4.15 | 3.00 | 62 | 56 | 771.39 | 1 244.94 |
| 1897 | 10 | 1 252 | 233 | 102 | 410.25 | 1 016 | 638 | 510 | 3 140.43 | 3.09 | 2.51 | 2.47 | 2.50 | 57 | 45 | 503.85 | 2 562.04 |
| 1898 | 12 | 1 370 | 246 | 114 | 465.58 | 1 110 | 738 | 539 | 3 462.08 | 3.12 | 2.53 | 2.28 | 2.00 | 166 | 42 | 729.38 | 2 936.71 |
| 1899 | 11 | 1 475 | 249 | 115 | 390.88 | 958 | 544 | 369 | 3 233.44 | 3.38 | 2.19 | 2.29 | 2.00‡ | 124 | 30 | 561.24 | 2 442.70‡ |
| 1900 | 11 | 1 541 | 216 | 116 | 370.83 | 1 130 | 666 | 432 | 4 351.53 | 3.85 | 2.82 | 2.50 | 2.00 | 112 | 27 | 590.82 | 2 162.67 |
| 1901 | 11 | 1 597 | 224 | 115 | 244.10 | 1 074 | 646 | 405 | 4 856.64 | 4.52 | 3.04 | 2.83 | 2.00 | 213 | 55 | 1 160.90 | 2 062.72 |
| 1902 | 11 | 1 544 | 220 | 135 | 260.60 | 1 030 | 610 | 395 | 3 927.01 | 3.81 | 2.54 | 2.36 | 2.00 | 172 | 20 | 442.43 | 2 601.19 |
| 1903 | 10 | 1 588 | 222 | 131 | 108.80 | 1 006 | 568 | 358 | 4 133.24 | 4.11 | 2.60 | 2.58 | 2.00 | 78 | 63 | 773.47 | 2 476.54 |
| 1904 | 11 | 1 743 | 232 | 141 | 211.58 | 1 189 | 681 | 391 | 6 163.44 | 5.18 | 3.54 | 2.98 | 2.50 | 178 | 84 | 1 701.18 | 2 300.65 |
| 1905 | 11 | 1 817 | 236 | 131 | 141.07 | 930 | 552 | 304 | 4 672.61 | 5.02 | 2.57 | 2.76 | 2.37½ | 112 | 67 | 1 060.14 | 2 906.34 |

* The publication of the Descriptive Index of Current Technical Literature was discontinued at the end of 1895.
† Deficit at close of 1894. Since then, each year has shown a surplus.
‡ During 1899, with an assessment of $2.00 per member, the Association made a rebate of $1.00 per member for the purpose of reducing surplus, making the actual charge only $1.00 per member, and reducing the assessment by about $1 400.

# APPENDIX J.

## Comparison of Conditions, 1903, 1904, 1905.

| | 1 | 2 | 3 | 4 | 5 | 6 | | | | 7 | | | | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Gross Cost of Journal. | | | | Net Cost of Journal. | | | | |
| | | | | | | a | b | c | d | a | b | c | d | |
| December 31. | Members on Mail List. | Total Pages in Journal. | Printers' Bills for Journal. | Cost of Illustrations.* | Cost of Manufacture. | Total. | Per Page. | Per Member. | Per Member per 1 000 Pages. | Total. | Per Page. | Per Member. | Per Member per 1 000 Pages. | Net Assets. |
| | App. H, Col. 2. | App. H, Col. 6. | App. D, Col. 5. | App. H. | App. D, Col. 7. | App. H, Col. 9. | App. H, Col. 10. | App. H, Col. 11. | App. H, Col. 12. | App. E. | | | | App. G, Col. 17. |
| 1903..... | 1 588 | 1 006 | $2 543.45 | $773.47 | $3 134.80 | $4 133.24 | $4.11 | $2.60 | $2.58 | $3 245.58 | $3.23 | $2.04 | $2.00 | $2 476.54† |
| Increase.. | 155 | 183 | 1 770.40 | 221.99 | 1 871.14 | 2 030.20 | 1.03 | 0.94 | 0.40 | 1 813.68 | 1.03 | 0.86 | 0.44 | .... |
| Decrease.. | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | 175.89† |
| Per Cent.. | 9.8 | 18.2 | 69.6 | 28.7 | 59.7 | 49.1 | 25.1 | 36.2 | 15.5 | 55.9 | 31.9 | 42.2 | 22.0 | 7.1† |
| 1904..... | 1 743 | 1 189 | $4 313.85 | $995.46 | $5 005.94 | $6 163.44 | $5.14 | $3.54 | $2.98 | $5 059.26 | $4.26 | $2.90 | $2.44 | $2 300.65† |
| Increase.. | 74 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | 605.69 |
| Decrease.. | .... | 259 | 1 551.42 | 569.57 | 1 535.44 | 1 490.83 | 0.12 | 0.97 | 0.22 | 1 164.33 | 0.08 | 0.76 | 0.41 | .... |
| Per Cent.. | 4.2 | 21.7 | 36.0 | 57.2 | 30.6 | 24.18 | 2.3 | 27.4 | 7.38 | 23.0 | 1.87 | 26.2 | 16.8 | 26.3 |
| 1905..... | 1 817 | 930 | $2 762.43 | $425.89 | $3 472.50 | $4 672.61 | $5.02 | $2.57 | $2.76 | $3 894.93 | $4.18 | $2.14 | $2.03 | $2 906.34 |

* Exclusive of printers' bills for paper and presswork on cuts, and inserting.

† The decrease in net assets, during 1904, is here made to appear much less than it is in fact, by the counting, as assets at close of 1904, of the Association's stock of Descriptive Index, $192.50, and of the Journal, estimated at $430.00, neither of which has hitherto been included, and by the omission of the cost ($241.34) of the December Journal from the statement of liabilities. Omitting the stocks of Journal and of Index from the assets, and including the cost of the December Journal with the liabilities, as heretofore, we should have: net assets, December 31, 1904, $1 436.81; decrease, $1 039.73. Per cent, 42.0.

## MEETING OF BOARD OF MANAGERS AT FRONTENAC, N. Y., JUNE 28, 1906.

PRESENT: Dexter Brackett, H. C. Toensfeldt, John R. Freeman, Gardner S. Williams, William A. Haven, also Fred. Brooks, Secretary; also, by invitation, John C. Trautwine, Jr., former secretary of the Board.

The action of the Chairman in inviting Mr. Trautwine to be present at the meeting was approved by unanimous vote. After discussion by the gentlemen present, and the reading of letters from A. P. Greensfelder, S. E. Tinkham, Dwight Porter, Charles W. Sherman, George W. Dickie, W. B. Wright and others, the following votes were passed, there being in each case five votes in the affirmative and none in the negative.

With regard to the question of allowing societies to subscribe for a number of JOURNALS less than the number of their members it was

*Voted*, That Section 2 of the Rules of the Board of Managers be amended by adding the words, " provided, that no society shall be assessed for less than twenty (20) copies of the JOURNAL, and provided, that no society shall be assessed for less than fifty (50) per centum of its membership at the time when the assessment is made."

In case this proposed amendment shall be made by letter ballot, under Section 2 of Article IV of the Articles of Association, Section 2 of the Rules of the Board will read as follows:

" 2. Each society shall be assessed in proportion to the number of names upon its mailing list at the time when the assessment is made, provided, that no society shall be assessed for less than twenty (20) copies of the JOURNAL, and provided, that no society shall be assessed for less than fifty (50) per centum of its membership at the time when the assessment is made."

With regard to inviting general discussion of papers it was

*Voted*, That the Secretary invite discussions on papers published in the JOURNAL, from all members of the associated societies and others, and that such discussions be collected, edited, and published by him in accordance with the rules governing the publication of papers in the JOURNAL, and such further rules as he may establish with the approval of the Board of Managers.

With regard to the suggestion of changing the JOURNAL to a quarterly publication, it was

*Voted*, That it is the sense of this meeting that a change of the JOURNAL from a monthly to a quarterly publication would be a step backward.

With a view to making known the advantages which societies may gain by joining the Association, it was

*Voted*, That the Chairman and Secretary be authorized and instructed to draft from time to time statements of the purposes of the Association, for publication in the JOURNAL.

Adjourned.

FRED. BROOKS, *Secretary.*

# Association of Engineering Societies.

Organized 1881.

VOL. XXXVI. MAY, 1906. No. 5



## REINFORCED CONCRETE CASING FOR THE PROTECTION OF PILES IN WHARF CONSTRUCTION.

By F. A. Koetitz, member of the Technical Society of the Pacific Coast.

[Read before the Society, April 6, 1906.]

During the many years of my experience in construction work I have often wondered why some good practical means for the effective protection of wooden piling against the ravages of marine life and even against general deterioration had not been found, and from time to time I have investigated many so-called "pile protections," always to find them wanting in one or another necessary essential. After giving this matter considerable study I have finally designed a system that I am certain will prove effective as a protection, which, being relatively cheap, can be used in many instances without any wooden piling, and it is the object of this paper to bring this system before the members of this Association.

The main feature of this construction is a reinforced concrete casing of practical length, or sections of such casing joined together, and with them either to encase wooden piles or to replace them entirely. When properly placed, in any of the ways in which these casings would be applicable, they are then to be filled with concrete and are ready to receive the superstructure.

The casings may be made of almost any desired diameter and with any preferred reinforcement, and for those of 18 in. to 24 in. diameter the shell need not be over $1\frac{1}{4}$ in. thick, larger diameters to be proportionately thicker, and the casings are, therefore, easily handled.

Fig. 2.

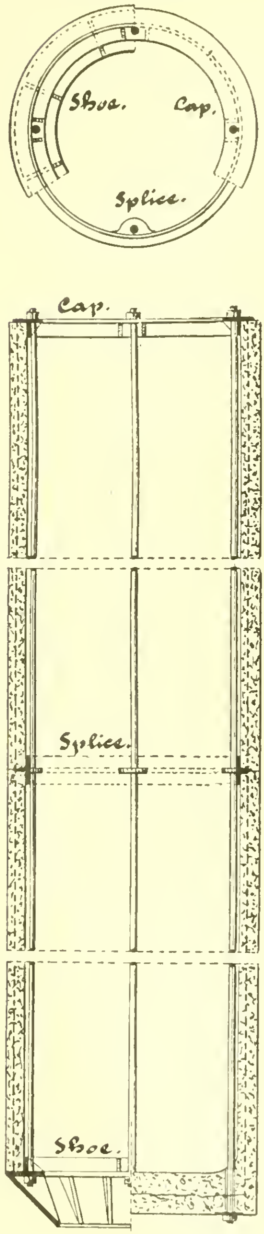



Fig. 1.

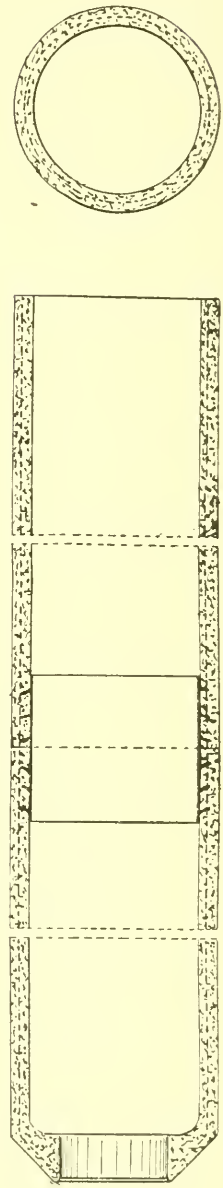


Fig. 1 shows two such sections of the casings joined by a simple sleeve that is inserted and properly connected at the place of manufacture. This connection is designed for light work only, such as protecting piles or certain portions thereof, or for repairing old piles. The bottom forms a shoe and at the same time serves as a guide in sinking the casing over the pile.

Fig. 2 shows a casing for heavier work, to be used more in the nature of a cylinder, with various sections joined together

Fig. 4.

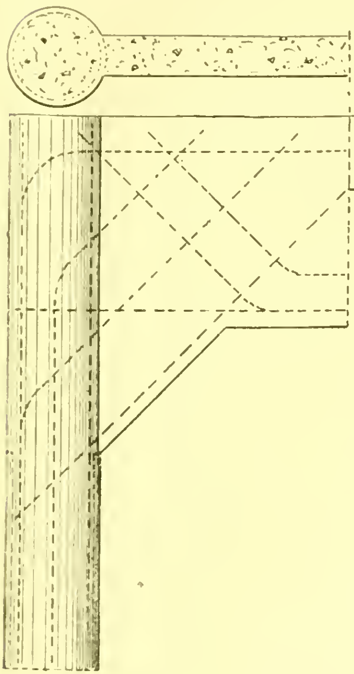
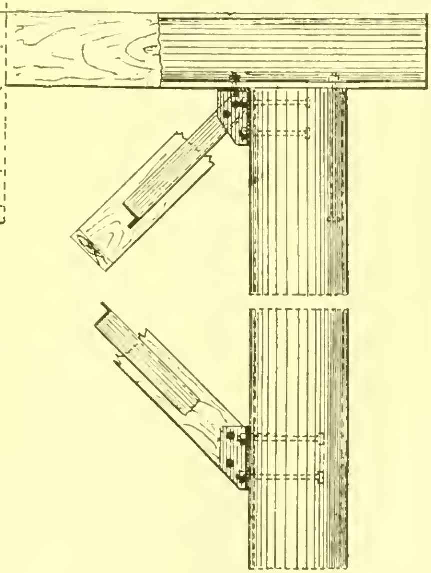


Fig. 3.



by proper cap, splices and shoe of metal, and the desired number of longitudinal rods. The shoe, if preferred, may be made of concrete similar to that in Fig. 1. In this case, the sections are assembled at the site of the work, as needed; they are supported, while being sunk in place, by rods, and when placed these rods are embedded in the concrete filling and form an additional reinforcing of the concrete and an absolute bond of the joints.

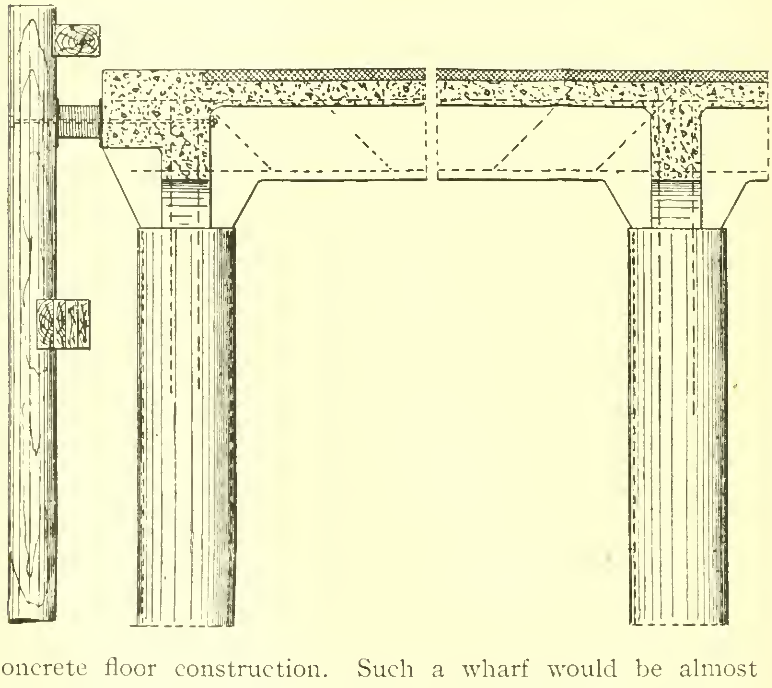
Fig. 3 shows these casings in the construction of trestle bents or piers, with cap of wood or steel, anchored to the interior

concrete, also with wood or steel bracing, attached in an approved substantial manner.

Fig. 4 shows the use of casings in conjunction with a reinforced concrete top work for piers or trestle where the head room is small and only a shallow bracing can be used. This combines the bracing and main girder all in one and will be found very rigid and durable.

Fig. 5 shows the use of the casings in the construction of wharves where they are admirably adapted to carry a reinforced

Fig. 5.



concrete floor construction. Such a wharf would be almost indestructible, requiring practically no repairs, and would be entirely fireproof. It should be obvious to any builder, that such a wharf must be a better investment than a wooden one under almost any condition. Where this wharf is used for docking vessels, it should be surrounded, of course, with the usual spring lines of wooden piling.

While the upper parts of these casings are suitable for any style of superstructure, the lower parts can be constructed and adapted to fit almost any kind of foundation.

Fig. 6 shows, perhaps, the most common requirements. This consists of driving a pile to its proper bearing capacity, of cutting off the pile, thus driven, at the desired level (or of cutting off an old pile at such level), of sinking the casing over the pile to the required depth for the protection of the pile, of pumping out the casing and of filling the interior with concrete. The lower shoe, as shown, forms a guide to keep the casing always at a certain distance from the pile, so as to assure at least a certain fixed thickness of concrete between the pile and the casing. The conical shape of the shoe tends to throw the soil or mud away from the pile and will allow only a minimum amount

Fig. 6.

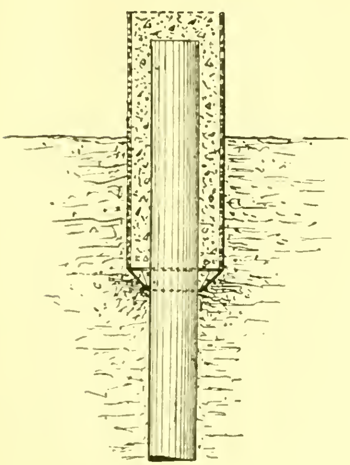
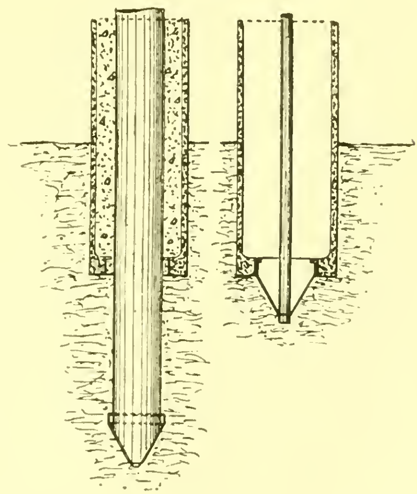


Fig. 7.



to enter the casing. It also serves to compress the soil at the bottom, which gives additional bearing capacity to the pile. It also forms a practical seal against the ingress of water between the pile and shoe, which will allow the water to be pumped out, and also any mud which may have entered, before placing the concrete filling.

Fig. 7 shows a case where, for some reason, it is desired to sink the casing with hydraulic jet first and then drive a wooden pile with a follower to a firm bearing through and below the bottom of the casing. The jet shoe of the casing is attached so as to disconnect easily from the casing, and is shaped so as to act as a shoe for the wooden pile.

Fig. 8 presents a case where rock or other firm stratum is reached. The bottom of the casing in this case is closed except for a connection in the center for a water jet pipe, by which means it may be placed in the usual manner. When proper bottom is reached, cement grout may be forced through this water pipe, which will serve to cement the casing to the bottom and give it a firm bearing.

Fig. 9 shows how an additional connection to the bottom may be made if desired. Drive with a follower a short steel pile, or pin, through the bottom of the casing after it has been sunk to place and bottom grouted. In this case the metal plate

Fig. 8.

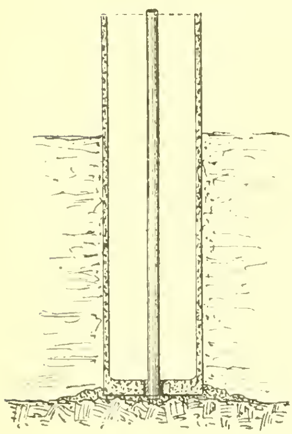
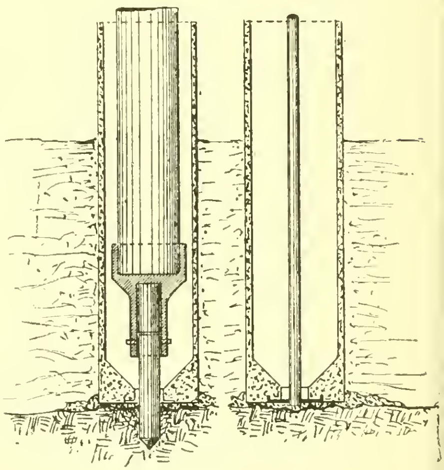


Fig. 9.



which closes the bottom of the casing, during the process of sinking, is so constructed that it will easily disconnect from the casing when the pile is entered, and the plate is of such thickness that it will readily shape itself to conform to the point of the pile when the pile is forced down to place.

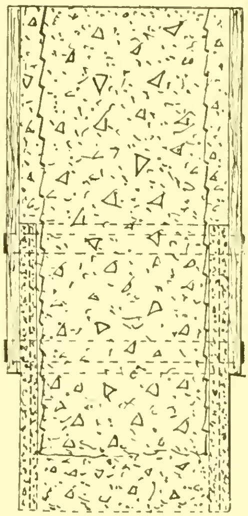
There is provision for making different lengths of piles by adjustment of the top sections. After the foundation is secured and casing built up, if the top section is found too long, this section may be removed and one of exact required length substituted. In case a section is found to be too short, or it is not convenient to remove it, when short, the pile may be lengthened, as shown by Fig. 10, by placing a circular detachable

form around the outside of the casing, placing the proper amount of reinforcing inside and filling the whole space with concrete, as desired. This same method may be used in constructing the upper concrete work shown in Fig. 4.

It would seem apparent, without going further, that it is easy to apply one or another of these examples to any requirement.

In closing, I may be pardoned for mentioning some of the advantages of this system over other similar forms of construction. Concrete, no doubt, being the principal requirement for good results, it becomes simply a question of using it in the best and most economical manner. If used in steel or wooden cylinders, the outer casing, it must be admitted, should be considered as only temporary, and the size of the concrete column is so made that, when the outer shell has served its purpose as a form, after due time, this concrete must stand by itself.

Fig. 10.



It being more or less difficult to determine just how successfully concrete in cylinders has been made, and also for various other reasons, the cross section of the concrete column is usually made large which gives a correspondingly large exposed surface to the action of water or waves in the pier. With this concrete casing the best and most durable part of the column is on the outside, and the cross section may then be materially reduced and, with it, of course, the exposed surface. This naturally leads to the question of cost or rather to relative cost of this construction. It may be easily demonstrated that since the volume of the concrete, which is the most expensive item, is greatly reduced, the price, complete in place, for the same length and bearing capacity of the structure is at least no more, and probably in most cases rather less, than that of any of the other methods used, even allowing for the more expensive outer casing, and I am very certain that its superiority is apparent.

[NOTE. Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by September 15, 1906, for publication in a subsequent number of the JOURNAL.]

## SMALL, VERTICAL, HIGH SPEED ENGINES.

By F. R. Still, Member Detroit Engineering Society.

Having had years of experience with various other makes of small engines, and comparing experiences of the past with those of the last three years, it has been found very difficult to avoid an almost exclusive reference to the one recently developed by an engineer associate of mine in the employ of the same company I am connected with.*

Therefore it is hoped you will bear with me a little, if my enthusiasm has biased my judgment in your estimation. Constant association with people, places and things always brings about a different aspect to us than to others not so much accustomed to them, which may be my case, though I can't believe it.

To most people, a small engine is something to be avoided if possible. It generally requires constant attention, frequent adjustment, is extravagant in steam consumption, and is difficult to get at to adjust or repair.

The main object of most manufacturers seems to be to see how cheap an engine can be built, not how good. This condition has so long prevailed that most people have concluded it is impossible to build a small engine from which the same results can be obtained as from a large one. The troubles to which small engines are incident are commonly accepted as a necessary sequence to their operation.

Efforts have been made to mitigate these evils by various schemes in design and lubrication, but usually the designer became so wrapped up in the one particular feature which started him into the design, that he lost sight of the other and more important details, never after being within speaking distance of them.

For example, one designer may start out to overcome vertical vibration, having a notion that in a multi-cylinder, single-acting engine there is less tendency to this vibration than in a single-cylinder, double-acting engine. An idea comes to him that if he could get compression on the downward stroke so as to slow up the movement of the reciprocating parts before they reach the end of the stroke, the necessity for heavy counter-

* American Blower Co., Detroit, Mich.

weights would be removed and a smoother running engine would be the result. So he sets out to accomplish this one thing, and very likely thinks out some scheme by which to introduce air compression toward the end of the downward stroke. He becomes so fascinated with this idea that all other details are almost totally neglected.

It would be fruitless for any one to attempt to make him see that the same thing can be accomplished in a double-acting engine, with a properly designed valve, so as to get the right steam compression at the end of the stroke.

Another designer starts out to build an engine with some "freak" valve, and every other detail is worked around this one central idea, regardless of efficiency.

Several have tried to reduce lubrication troubles, principally by splash oiling, with more or less success. If an engine is always in one position and always runs at high speed, this system may give fairly satisfactory results, but it is unreliable on board ships and at slow speeds. Furthermore, it is extravagant in the quantity of oil consumed. These examples will serve to show the usual trend of effort for the improvement of small, vertical engines.

From experience and close observation it was decided that fully 80 per cent. of the small engine troubles are due to improper lubrication; whereas only about 10 per cent. are due to inadequate proportions and finish of the working parts, and the other 10 per cent. to the neglect or ignorance of the operator.

It will thus be seen that if such conclusions are correct, the efforts of most of the designers have been in the wrong direction; that greater attention should be paid to proper lubrication and refining some of the details than to the production of something entirely new, with which there are likely to be as unsatisfactory results as before. Anything radically new is more likely to be misadjusted by the average engineer than something built on lines with which he is perfectly familiar.

Being so satisfied that these conclusions and deductions were correct, it was decided to carry them into effect, if with no other result than to prove their fallacy.

To get away from any fixed notions, and to gain new ideas from the practice of others and, further, to give "an opportunity to criticise somebody else," an engine designer of long experience in some of the best shops in this country was engaged.

Before him were spread these ideas, also what he was expected to accomplish. This briefly was as follows:

1. An engine that could be sold with a guaranty that it would run three months or more without requiring any attention, either to the oiling system, or for adjustments, except the filling of the sight feed cylinder lubricator.

2. An engine that would be economical in the use of steam and oil.

3. That could be easily adjusted and not liable to easily get out of adjustment.

4. That could be used anywhere and for any purpose that an engine can be used for.

5. That had ample bearing and wearing surfaces to make it long lived and unlikely to overheat at full load.

6. That it should be constructed of the best materials for the purpose intended.

7. That it should be devoid of any semblance to "freaks" of every sort; and last, but not least, and, perhaps, the most difficult of all, it must not be so costly to build as to make the selling price prohibitive to the average buyer.

How well these requirements have been accomplished is shown by the satisfactory reports since obtained from the engineers having charge of them.

Being so thoroughly impressed with the importance of a good system of lubrication, the first step was to work out something more effective than previously used.

It does not take much thought to arrive at the conclusion, that if metal does not run on metal, but is always separated by a heavy film of oil, there can be very little wear. The problem then settles down to the production of the necessary heavy film.

In looking over the many systems for lubricating engines, the most rational seemed to be forced lubrication by means of a pump. But experience shows this has many defects. The oil being under pressure necessitates extreme care in adjustment, as any bearing being looser than another vents the entire system and destroys the desired effect. Again, any foreign material that may get into the small tubes or grooves which are an essential part of this system will be rammed in tight by the oil pressure.

To overcome these objections it was decided to adopt a gravity flow, the oil being lifted by a pump to the top of the frame, from which elevation it would flow downward by gravity. In this way large tubes can be used; the velocity of the oil will be rapid, the volume of oil in circulation will be much greater,

it will not be necessary to have the bearings tight, neither will they all have to be adjusted exactly alike, and any foreign matter will be washed out, instead of being rammed in.

Being satisfied that this came close to the ideal way of producing the flow of oil, the next step was to distribute the oil along the bearing and wearing surfaces to completely separate them by that all-essential film.

For ages it has been common to groove the upper or lower half of the journal box or perhaps both. There are as many ideas on the proper way to groove a box as there are people in the business, and there are evidently many more who have no ideas at all, judging from the way it is sometimes done.

Considering the question from a mechanical standpoint, it is at once apparent that an oil film takes up space, so a bearing cannot be tight or the oil cannot get in unless it is forced in at a pressure greater than is exerted on the journal.

The thicker the film, the more space there must be between the metals, hence a loose bearing is desirable if it does not cause pounding.

When the crank is on the downward stroke, it pushes the journal away from the upper part of the bearing. The shaft is also rolling in the direction the crank is traveling. Hence, the oil should enter at the beginning of the gap which intervenes between the shaft and bearing and thence be rolled up into the remaining space by the rotation of the shaft. The gap naturally begins at one side of the circumference of the shaft, so the oil grooves should most naturally be on the sides.

After the crank passes the lower center on the up-stroke, oil should flow in from the groove on the opposite side in the same way. These grooves can thus be made large, say from $\frac{1}{4}$ in. to $\frac{3}{8}$ in. in width and the whole length of the bearing metal.

The same scheme is applicable to the oiling of the main bearings, crank pin, crosshead pin, eccentric and governor weight pin, and it works to perfection, better even than was ever thought possible.

To gain some idea of the way it is working, it may be in order to point out a few cases.

Cards were sent to nearly all the purchasers of these engines, asking them to have their engineer answer the questions printed thereon. The questions were as follows:

Size of engine?

When installed?

Revolutions per minute?

Steam pressure?

How often has oil been added since starting?

Quantity of oil added each time?

How often have adjustments been made?

Where have adjustments been made?

Replies were received in nearly every instance, and with the exception of five or six, they all ran over five months without any adjustments or additional oil.

One most exceptional case was at Davenport, Ia., where a 14 by 7 in. low pressure engine is running in a school building. The speed is 180 rev. per min., the steam pressure 40 lb. At the start 4.5 gal. of oil was poured into the base and in two years only one gallon has been added and one adjustment made, which was to the crosshead pin.

In New Orleans an induced draft fan was installed on an ocean tug, which is driven by a 5 by 5 direct connected engine. The steam pressure is 110 lb. The engine runs about 360 rev. per min. The outfit was installed in February, 1904, and up to November 29, 1905, about twenty-two months, only three gallons of oil had been put into the engine and one adjustment made to the crank pin. This engine runs continuously, 24 hr. per day for three or four days at a time. It is seldom that it ever stops entirely, as it is turning over slowly even when the tug is tied to a dock. It is located in a very hot place over the boiler and withal is operated under about the worst possible conditions.

At the plant of the Trexler Lumber Company, Allentown, Pa., is another engine driving a blower which is attached to a dry kiln. This was installed February 5, 1905, and up to November 18, 1905, only one gallon of oil had been added and one adjustment made to both the crank and crosshead pins.

This engine runs steadily at 285 rev. per min., 24 hr. per day, without stop for Sundays or any other day.

These few citations are sufficient to show the remarkable effectiveness of the oiling system.

There were many other problems in the perfection of this system which had to be worked out, that were, perhaps, equally as interesting in connection with this oiling system. For instance:

After the oil has performed its usual functions it must be filtered, cooled and the water separated from it. Any of the usual methods of filtration were found unreliable, as they all allow pieces of lint or grit to pass through. After much experi-

menting it was found that a plain closely-woven cloth suspended by four hooks from each corner of the frame, hanging just below the crank and above the oil in the base, gave the best results. All the oil dripping down from above lodges on this cloth and passes through to the reservoir below. Any foreign matter is left on top and has no tendency to leave the upper surface. Simple as it is, it has been surprisingly effective. As an extra safeguard a fine copper wire screen of ample area was attached to the pump suction and another to the discharge, both being easily removable for cleaning.

Another source of possible trouble which had to be guarded against is the loosening of core sand from the frame.

No matter how much care may be exercised in cleaning a casting, some sand is sure to stick for a while, loosen later and cause serious trouble.

To prevent this the frame is painted inside with two coats of thick white enamel. It took a lot of experimenting to get an enamel that would stand the heat, moisture and oil without softening, but it was finally procured.

The pump first adopted was of the plunger type, actuated by an eccentric on the shaft. It was thought too complicated, however, and was abandoned for a gear pump. On the shaft is a large bronze worm with coarse teeth into which meshes a small spur gear attached to a shaft supported at an angle of about 45 degrees. The pump gears are within a case attached to the outside of the frame close to the bottom of the base, where they can be gotten at at any time.

The discharge pipe from the pump is 0.75 in. diameter, and extends up inside of the frame to the top, where it discharges through a sight feed glass, so the engineer can easily see if the oil is flowing properly.

The oil then empties through a wire screen into a small tray, through the bottom of which latter project the various oil tubes nearly to the top of same. Each tube has a fine slit cut down the side of it to the bottom of the tray, so as to equalize the flow of oil into them all.

In adjusting the engine for this system no bearing should be so tight as to make it impossible to easily slide the connecting rod or shaft along parallel with its axis.

The success attained with these engines, while largely due to the perfection of the oiling system, could not have been attained if it alone had been the only thing carefully developed.

First of all, good material of the proper kind has to be used, and all the pins, rods, shaft, piston, valve, crosshead shoes, etc., must be ground on centers to a true diameter and smooth finish.

The shaft is a forging with suitable counter weights fastened on.

The connecting rod is a drop forging finished bright.

The crosshead is cast steel having brass shoes, wedge shaped and adjustable at the top and secured with lock nuts.

The crosshead pin is a special composition of a very fine grain and hard enough to take on a very smooth finish. This pin in combination with the brass used will not cut. The brasses have been set up as tight as they could be driven on a dry pin and the engine run all day without the least signs of cutting.

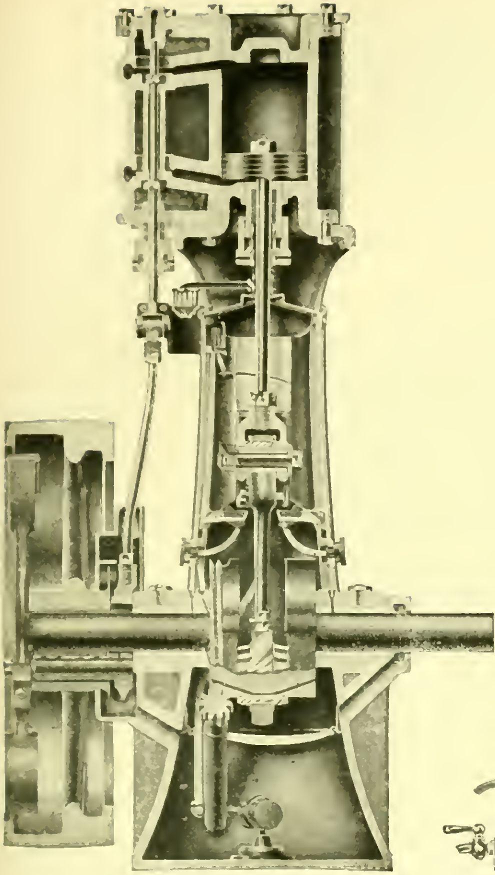
The piston rings are roughed out, cut, drawn together and clamped. They are then ground to the cylinder diameter. The crank pin brasses are lined with the best quality of Babbitt metal, peened in and scraped to a perfect surface. Adjustment to these brasses is accomplished by two tap bolts turned out of hexagon steel, threaded on the lower ends. Above the nuts the tops of the bolts are turned down to a smaller diameter and threaded again for a lock nut. The two tops are joined together by a yoke-shaped washer which is between the nut and lock nut to prevent either of the bolts working out if one of the lock nuts should loosen.

The fly wheel is so designed that the greater part of the weight comes in a plane close to the end of the bearing, thereby relieving to a great extent any strain on the shaft. The inclosing panels are held in place by a single milled thumb screw, thus overcoming the necessity for taking out a dozen or more screws to get off the cover plates.

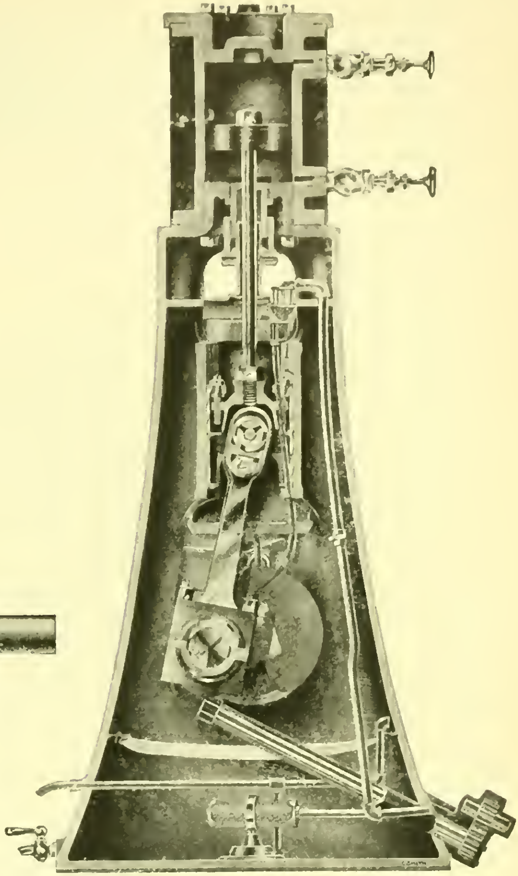
Every engine is set up, given a day's run under full load, and then taken down, carefully inspected, and if found in a satisfactory condition is re-assembled, indicated and adjusted before leaving the shop.

Due to the high speed, small clearance and a well fitting valve and piston the steam consumption has been brought down to an average of less than 37 lb. per h.p.hr. for a 6 by 6 engine, with 100 lb. pressure, when running 500 rev. per min. with full load.

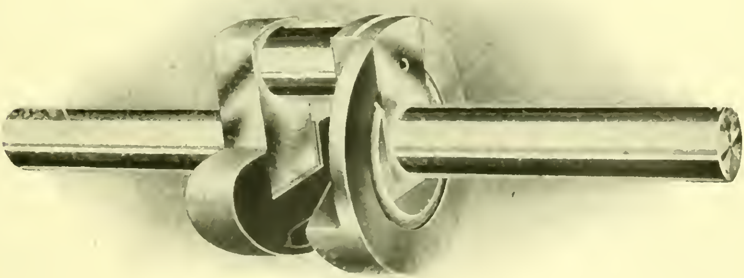
It is rare that the same economy is attained with other engines of the same size, as most of them take from 60 to 80 lb. per h.p.hr.



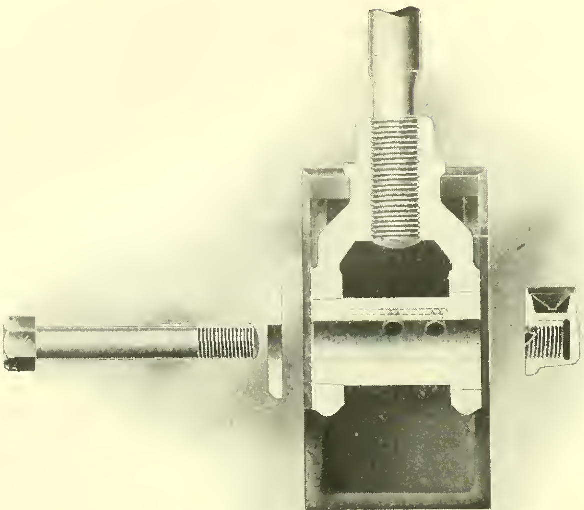
Longitudinal Section through the Engine.



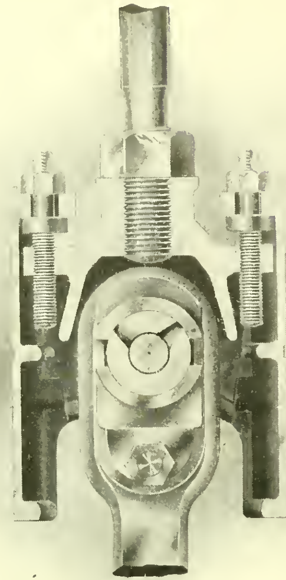
Transverse Section through the Engine.



Crank Shaft.

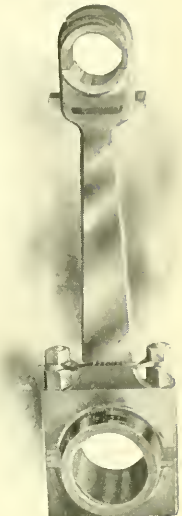


Crosshead.



Crosshead.

Connecting Rod
Bolt.



Connecting Rod.

It really seems as though about all has been accomplished in the design of these engines that can reasonably be expected in any engine.

They are machines, and as such are not "fool proof," but they can carry a heavy load, run at high speed, do with less attention and still perform their duty better than can the majority of engines.

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[NOTE. Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by September 15, 1906, for publication in a subsequent number of the JOURNAL.]

## FROGS AND SWITCHES.

By Robert E. Einstein, Member of the Engineers' Club of St. Louis.

[Read before the Club, January 3, 1906.]

In the consideration of frogs and switches, the section and quality of rail is an important factor. As generally designed they depend largely on the rail, and the durability and design of rail section has much to do with the safety and economy of their use.

The metal in our steel rail does not seem to come up to the requirements of modern traffic. The weight of rolling stock is constantly increasing. One hundred thousand lb. capacity cars and 100-ton locomotives are now in very common use. The volume of traffic has increased, so that it is probably tenfold what it was a few years ago. These are the conditions that the rails of the present day must meet. As to whether they are coming up to them or not, we have only to read the reports and discussions of the associations devoted to the maintenance of roadway and track. We find cases of 80-lb. to 100-lb. rails being badly worn and in poor condition after five or six years' use. We find innumerable reports of defective and broken rails, and a general feeling of distrust in the product of our rail mills.

In looking for the cause of these unsatisfactory conditions the general opinion seems to be, that the fault lies not in the chemical composition or cross section, but in the methods of rolling, and it is to bring about a better practice in this regard that most of the present efforts are being directed. The subject of rail, its composition, section and treatment in rolling is one that I can hardly do justice to in the limits of this paper. The importance, however, of the rail to that of the matter in hand will permit a few words relative to designs and sections in common use on steam railroads.

Up to the year 1893, the railroads, notwithstanding innumerable discussions on the matter by various bodies connected with their maintenance, had never been able to agree on a standard section of rail. It was the custom of the roads ordering large quantities, to have their engineers design a rail of the weight decided upon, intended to embody all the features

of perfection, and of such composition as to insure durability. In consequence, there developed numerous sections differing, more or less, from one another; in some the heads tapered up, others had sides of head parallel, and a few had heads with wide flat surfaces tapering down. For the same weight per yard, the heights varied one-half inch, bases one inch in width, and there were innumerable shapes and sizes for approximately equal weights, each having some feature to meet apparent former defects, or to conform to peculiar conditions of traffic on the road to be used. Something like fifty sections of rail weighing about 60 lb. per yard, the weight in general use at that time, were designed. This was very expensive all round. The rolling mills had to furnish or change rolls for every different shape. The railroad company had to keep on hand a various assortment of angle bars, fish plates, frogs and switches with their parts, to suit the numerous sections. Mills were hardly ever able to supply small quantities for renewals and extensions, which led to the use of a further assortment on the same road, with its consequent unsatisfactory results.

These conditions existed for a long time and were recognized as being anything but the best. It remained for the American Society of Civil Engineers to adopt, in 1893, what are termed the American Society of Civil Engineers' sections. The sections thus adopted vary from 20 lb. to 100 lb. per yard. The general features embodied are: Height equals width of base, sides of head parallel, top of head and sides of web to have a radius of 12 in., fishing angle in relation to center line 13 degrees. The radii of the corners vary slightly for the different sizes, the object being to maintain practically the same proportions and form for all weights. The head of these rails contains 42 per cent., the base 37 per cent. and the web 21 per cent. of the metal.

Within 10 years from the time of adoption something like 75 per cent. of the rail rolled in the United States was of the American Society of Civil Engineers' sections, which tends to indicate the favor with which a standard in this respect was taken up by mills and users. The experience of these years, however, in the use of American Society of Civil Engineers' sections, has tended to establish some changes. By comparing the American Society of Civil Engineers' sections, with a section of equal weight, 85 lb. per yard as recently adopted by some of the leading western systems, we find a tendency to get a deeper and a narrower head. The thin head of the American Society of Civil Engineers' rails is one of the apparent defects developed in their

use. This weakness of the head is more noticeable in the heavy sections, and experience has shown that some of the poor results are due to this cause. In frogs this is brought out to a greater degree than in ordinary usage, as the blow imparted by wheels in passing over flange way, or opening, is, in many cases, borne directly by the overhanging part of the head, and the thin metal causes it to pound down and break off very rapidly. The deep-headed sections are much more satisfactory in this respect.

In their earliest forms switches and frogs, like rails, were very crude and simple. The switch was of the stub pattern, in which the diverging rails were cut at a point where the gage lines are about 5 in. apart. The ends were held in position by cast-iron head chairs, so formed that they provided a seat for moving the sliding or switch rails from one of the stub ends to the other. The two sliding rails were connected and held to proper gage by bridle rods, connecting to base of rail by claw formed at each end, and thrown to position by some form of switch stand to which they were attached by means of a connecting rod. This form was used a great many years and is still found on unimportant sidings and very old tracks.

There were some changes made in the stub switch, tending to overcome its objectionable features which developed in the head chairs. To allow for the running of rails and the free movement of the sliding rails, a space of about one-half inch was necessary between their ends and the stub ends of turn-out. This caused severe pounding and consequent loosening and breaking of head chairs, and made the head block on tie upon which these chairs were spiked very difficult to keep up. As the speed and weight of rolling stock increased, trouble from these defects became more pronounced, and numerous derailments were caused by the weakness of the track at this point. The improvements made were in the construction of the chairs by substituting wrought for cast iron, and modifications in the form of stub ends by beveling to a V shape. But none of these overcame the practical breaking of the track with its consequent weakness.

For this reason the stub switch gave way to the split pattern now in almost universal use. This type of switch, it is claimed, was introduced in England as early as 1825, but did not come into general use until recent years, probably on account of the cheapness and simplicity of manufacture of the stub design.

In the split switch we have two of the rails unbroken, forming

what is known as the stock rails. The points or bevel rails are made by planing to proper shape rails of the same section as the balance of track. The usual length is 15 ft. or one half of a 30-ft. rail. In connection with 33-ft. rails, length is sometimes 16½ ft. with the same idea in view. In special cases points are also made as short as 7 ft. 6 in. for very short turnouts, and as long as 30 ft. for easy leads such as are used in cases where single track connects to double, or wherever high speed must be maintained in connection with diverging tracks. To overcome the weakness due to planing away a great part of the original section the points are sometimes reinforced by strips of iron or steel bolted or riveted to the web. This reinforcement is also made in the form of a tee or angle to give additional lateral stiffness.

Like the stub switch, points are held to proper gage and position by bridle or switch rods. They differ in form and manner of attachment, however, on account of the rail being greatly reduced in section at some of the points of application, and because there is not the required space for applying rod of the claw form. There are a number of methods of connecting points to rods — all designed with the idea of allowing a certain though small amount of play for the free movement of the points. A common and very satisfactory form is the fork attaching with pin to the base of rail. This keeps the points well up to their proper working position, and has no bolts or extra pieces to get loose, rattle and give trouble. It also has the advantage of being at the bottom of the rail, away from liability of coming in contact with wheel flanges. Another form of attachment in general use consists of pressed steel clips or brackets, bolted to web of rail, with recess open on one side for the ready application of rods. Pins or bolts pass vertically through clip and rod holding points to proper gage and allowing for free movement. These two are only examples of the many in use.

The rods were formerly made to fixed lengths, but recently an adjustment of some kind to allow for variation in gage or throw and to take up wear and lost motion is incorporated, either in the rods or clips. There are a great many ways for providing for this adjustable feature. The simplest, and probably the most common, is the turn-buckle or swivel. This is simple and easily understood by the class of labor usually employed on track and, when properly made, makes a very acceptable type of adjustable rod. Other forms, such as wedges,

eccentric bolts, saw teeth formed on rod, and a series of holes allowing for changes in length, are used and have various advantages that have led to their adoption.

In the old forms of split switch having rods of fixed length and points without reinforcement, four rods were considered necessary. This probably came about through its evolution from the stub switch. There is hardly any good reason for the use of more than one, or at the most two, rods on a 15-ft. or $16\frac{1}{2}$-ft. switch, except, it is claimed, in case of breakage to point, that the back rods tend to hold rails to safe position for passing trains. This possibly accounts for the long-continued use of the four-rod switch. With reinforced points the reinforcement serves as a protection in case of breakage, as well as stiffening to points, and one or two rods are enough to keep them at proper distance apart, and to move and hold them to position.

Besides the points and rods, split switches require plates, which reduce friction of moving rails, form a shoulder to hold stock rail to proper position and keep center of point slightly above the stock rails. The latter function is one of great importance, preventing the liability of a side strain and consequent turning over of these rails, due to worn treads passing from heel to point of switch. Many of the accidents reported as caused by spreading rails can be attributed to this cause.

Plates are usually made from $\frac{1}{4}$ in. to $\frac{1}{2}$ in. in thickness and from 4 in. to 8 in. in width. The part of plate under point is raised to allow for an elevation of from $\frac{1}{4}$ in. to $\frac{3}{8}$ in. to switch point above stock rails for the purpose set forth. These plates are usually placed under about $\frac{3}{4}$ of the length of point. They are designed to allow for the use of a rail brace against outside of stock rail, serving to hold track to gage and prevent the tendency of stock rail turning over from side strains. The plates directly under points are often combined in one, extending across the track and forming a gage plate.

There have been other forms of switches designed to overcome apparent defects of the split pattern, but very few of them have come into general use. The Wharton switch is probably the only one that has had extensive application. In this the wheel flanges are raised over the main rail on inside of turn-out, while a point similar to split switch is used on the opposite side. The objection to this switch is the excessive cost and the fact that a slow rate of speed is necessary in taking the turn-out track, making this type only adapted for turn-outs where siding has infrequent use.

The means of operating switches except at terminals, and locations where their number within a limited space permits the use of interlocking plant, is by some form of switch stand.

The types of stands vary according to their use. For main line a stand having signal from 7 ft. to 20 ft. in height for indicating position of switch, with lamp attachment serving same purpose, is used. It is the practice on some roads to connect important switches with a distant signal located from 1 000 to 1 200 ft. from switch, and so connected that this signal always shows position of switch, giving the engineer an opportunity to discover in time any chance misplacement.

With the block system this safeguard is, of course, provided through connection of signals with the switches, but as a very small proportion of our mileage is thus equipped, the distant signal in connection with main line switches affords a great factor to safety in operation.

In yards where switches are moved frequently, and where the temptation and chances of running through them are great, the stand best adapted is a form of automatic ground throw with lever throwing parallel to track. The automatic feature allows for this running through switches without serious results, the lever being of such weight that the action of wheels against the points throws it over. Making the movement parallel to track permits its use where distance between the tracks is very small, thereby economizing space. Yard stands are equipped with small targets and lamps which are kept close to the ground to avoid interference with cars.

In the form, size and color of targets there is a great variety. The *forms* of signals should differ for clear and siding positions, though sometimes this is not the case. In *color*, white is always the clear position, while red or green is the opposite indication. The night signals are made to conform to the practice of road, either red and white or red and green as the custom may be. There has been a great deal of discussion on the matter of signal colors, and a uniform practice in this respect is much to be desired.

In the construction of switch stands cast iron, malleable iron, wrought iron, cast steel and structural shapes are all used. It is important to avoid complicated mechanism, interference by snow and ice, and to allow for easy operation, repair and renewal of parts, while cost has its usual consideration.

The frog is that part of turn-out where the lead rail of switch crosses or intersects the main rail. The term is also applied to

the intersection of two tracks, which properly form four frogs, and is usually referred to as a crossing frog, or simply crossing.

Frogs have been standardized as to angle; that is, there are certain angles or numbers in general use; but the construction or types vary a great deal. In the standardization of angles they are termed according to *number*, which properly is the relation of the spread or divergence of rails to the distance at which it is measured. Thus a number nine or a one in nine frog indicates that the spread is 1 ft. at a distance of 9 ft. from the intersection of gage lines. The number, of course, determines the angle, being the difference in the direction of the rails along the running line: thus a spread of one in nine makes angle of 6 degrees 21 minutes. This angle likewise determines degree or radius of turn-out curve and the lead or distance from the point of switch to point of frog. Referring to frogs by number greatly simplifies the matter of turn-outs. Trackmen easily understand the difference between the sizes, and the engineer is able to stake out his turn-outs according to uniform rules, and to design his yards to conform to the standard numbers or angles adopted to suit the various conditions. As the number or angle determines the radius or degree of turn-out curve, it is simply necessary to establish certain sizes of frogs for the different purposes. For main line turn-outs and cross-overs frogs from numbers nine to eleven are the recognized standards in common use. It is, of course, impossible to adhere to one angle under all conditions, but it is the endeavor to conform in all but special cases to the angles adopted as a standard. For very easy turn-outs such as the merging of double into single track or where high speed must be maintained, frogs from No. 18 to No. 25 are used, while in close places where space is limited, frogs as small as No. 3 or No. 4 are sometimes necessary. The latter are, however, special cases to be avoided if possible, as it makes a very sharp and unsatisfactory curve.

The usual yard frog is a No. 7; Nos. 6, 8 and 9, however, are in common use for this purpose. The angle is determined by the space available, and with an idea of economy of time and space for rapid, easy and safe movements. One of the greatest economizers of space in yards is the slip or puzzle switch This is really a crossing or intersection of two tracks, at such an angle as to permit the use of ordinary end frogs in combination with four switches, thus giving four movements within its limits. The angle to which slips can be applied is limited by the same conditions that govern frogs, that is, an angle less

than No. 6 makes the curvature too sharp for practical use. On slips longer than No. 7, it is necessary to make the center frogs of the movable point pattern to prevent derailment from inadequate guarding of the center frog points, which is practically impossible on account of frog points being exactly opposite.

In short slips the wings of center frogs offer the same protection at this point as do guard rails opposite end frogs, but when angle exceeds No. 7, the two points of each center frog become so far apart, that ordinary wheels are sometimes inclined to get the wrong side with serious results.

The use of movable center points instead of rigid center frogs obviates the necessity of guard, and makes a safer and more durable slip. The only objection to this form is the fact that these points must be thrown the same as a switch, and the trouble experienced has been that the switchmen do not always move them to the correct position with relation to the end switches. This, however, has been overcome by the proper connection of the end switches and center points, and the use of interlocking switch stand with required movements. The center points are thus always held in the proper relative position to end switches, and no derailment can occur from this cause.

Frogs may be divided into several classes: For main line use American railroads have now practically adopted the spring rail frog; for yards and ordinary sidings away from high speed traffic, the rigid frog is generally used. In the construction of spring rail frogs there has been a number of improvements during the past fifteen years, tending to increase safety. The earlier forms of this frog were so imperfect that a great many serious accidents have been traced directly to their use, and on some roads they became such a frequent cause of complaint that the use of spring frogs was for some time abandoned. The defect developed was the long loose rail on the main line. This rail, as the name of the frog implies, is held to proper position by a spring, so arranged that under ordinary conditions it lies close to the point of frog, forming a smooth surface for passage of wheels on the main track. In taking the siding this loose rail is forced out by the action of the wheel flanges, the fish plate or angle bar at its end acting as a hinge for its movement. By frequent use this loose rail has a tendency to rise or stand proud of the surface of frog, and although precautions were taken to prevent this, it was very often the case that a combination of this long loose rail with the tendency to rise and a badly worn

wheel, acted so as to turn over the rail with consequent serious results.

In the spring frog having hinged spring rail, the possibility of accident from this cause is entirely averted. The spring rail is only movable or loose for about 2 ft. on the main running line. It is reinforced by an outside rail which in addition to strengthening this weak part of the frog gives the movable part so wide a base bearing that any possibility of the rail turning is entirely overcome. There are additional safeguards and improvements in this frog that make it practically as safe as the rigid, with all the advantages in durability and smooth riding of the spring frog.

Other forms of spring frogs embodying the old principle of the long loose rail have been equipped with improved devices, and under ordinary conditions are reasonably safe, but even the chances of accident, when it is possible to prevent it, should condemn the use of any but the most improved devices where the lives and property of the public are concerned.

In the construction of rigid frogs three general forms are used, — the bolted pattern, in which the parts are held together by means of bolts; the plate riveted, having the rails riveted to a large base plate, and the clamp or yoke design with steel or wrought clamp and wedges to hold rails and filling blocks rigidly together.

Rigid frogs, and crossings which are practically a combination of frogs, have the very necessary evil of a flange way or opening for the wheel flanges. The passage of the wheels over this opening, with the heavy loads of modern equipment, is the cause of the rapid pounding out and frequent renewal of frogs. When we consider the difficulty experienced in keeping up an ordinary rail joint, where the distance of from $\frac{1}{32}$ in. to $\frac{1}{4}$ in. between the rails causes a rapid battering of the ends, we can comprehend the effect of the same loads on the crossing or frog where this opening is necessarily increased to from $1\frac{3}{4}$ in. to 2 in. It is to overcome the rapid pounding out of rigid frogs and crossings that a great deal of thought and experiment has been devoted for the last few years. In construction we have arrived at a point where the frogs are so rigidly put together that it is no longer a question of working loose and shaking to pieces. It is clearly a case of providing one of two things: to do away with the cause of pounding, or to overcome the effect. Towards the first, the spring frog on main line provides unbroken surface for passage of wheels, but only on one side of frog; we have

likewise the double spring frog doing away with opening on both sides. The latter is an improvement over the rigid, but the constant movement, due to each wheel acting against the spring, makes this form of frog extremely hard to maintain as the parts get loose and fall apart; although the life is considerably longer than the ordinary rigid type.

On lines similar to the double spring frog the sliding or movable wing rail frog offers also an unbroken surface, and on a frog of this kind built on the principle of the hinged spring frog we have again the advantage of short moving rails having fixed ends to rigidly bolt the connecting rails. Frogs of this type have had, under the hardest conditions of service, a life of three to five times that of ordinary rigid frogs.

Crossings of the smaller angles are built on the same lines as frogs, and involve the same weakness and defects. As the angle becomes greater or nearer to 90 degrees the construction changes to suit conditions.

From 35 degrees to 90 degrees crossings, as generally made, consist of a frame or filler of wrought iron or steel, to which are bolted the rails. The filler is a rolled section fitting the fishing angle of rails with required flange way opening and depth. The rails are milled or planed to form at the corners the necessary bearing for tread and flange way for wheels, and are further supported by straps fitting between head and base from 1 in. to 2½ in. in width through which pass the bolts that hold these parts rigidly together. Plates from ¼ in. to 1 in. in thickness are placed under corners to distribute the shock or pound to the ties.

The most important and generally adopted improvement in recent years in the construction of crossings is the reinforcing or easer rail. This rail, in addition to providing strength to the structure, acts as a means of preventing the overhanging wheel tread, often badly worn, from striking the abutting rails, which causes the rapid loosening and shaking to pieces of the crossing.

The use of the heavier rails, reinforced construction of frogs and crossings solidly bolted together has resulted in the loss of that elasticity that the lighter forms of construction embodied. As previously stated, it was either necessary to remove the blow or overcome the effect. The tendency on heavier construction is to increase the force of the pound, as the shock is borne directly by the rail and the stiffness of structure does not transmit it to ties and road bed. If our rail was of better quality this would be overcome to a great extent, but with the poor metal

and the thin heads of the American Society of Civil Engineers' sections the question of increasing the life of crossings and rigid forms of frogs has led to the use of a metal at the points of wear that combines with hardness the quality of toughness to prevent fracture. This form is known as hard center construction, and is now receiving a great deal of attention.

The idea of making the parts of frogs and crossings subject to shock of a harder substance than rail is by no means of recent date. Street railways have used this form almost with the advent of electric traction. In this service, however, there are several important conditions that do not enter into steam service. The speeds are, under no condition, what they are on steam railways, and when they do approach the high speeds of main line service as on interurban roads, the same forms of construction are usually used. It is also the general practice on account of the narrow treads of street railway wheels to give the wheel flanges a bearing in passing over the flange ways of frogs and crossings. At slow rates of speed this is not liable to injure the wheels, and does away with a great deal of the shock. These conditions, and the deep solid forms of construction in street railway practice, have practically made hard center material the recognized standard for this service.

On steam railroads where we are confronted with higher speeds and cannot allow a flange bearing, it is possible that extreme hardness when generally used will save on the frogs, but may develop other defects and expense that more than counteract the economy in this respect.

At present frogs with hard centers are being tested under conditions where traffic is exceedingly hard, and where maintenance of frogs forms a considerable item. There are many places, where 60 to 90 days represent the life of an ordinary frog. If the substitution of the hard center of the sliding feature adds to the life enough to pay for increased cost, and offers no counter expense to equipment, there is no doubt that the future will see increased use of these types, even at an outlay of from two to five times the cost of ordinary construction.

The metal that has thus far proved the best for hard centers is a cast steel containing a certain percentage of manganese. The cost, of course, runs high as compared to other forms, but for hardness and toughness, the qualities most desired, it seems to fill all requirements. The expense attending the use of this metal is further augmented by the cost of working, as its extreme hardness makes it necessary to cast it very closely to its final

form. All holes must be cored, as no tool steel has been found of sufficient hardness to drill it, and all surfaces and joints must be ground, because planing or milling is impossible for the same reason.

The failures in this metal due to improper mixture or handling sometimes cause cracking or chipping. When this is the case its use is attended with danger; but this defect is not insurmountable, and we may expect to see the use of hard wearing surfaces not only in the future development of frogs, crossings and switches, but also in the rail, thus bringing about a much-desired factor in the development of our railroads.

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[NOTE. Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by September 15, 1906, for publication in a subsequent number of the JOURNAL.]

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## A SUGGESTED SOLUTION OF METROPOLITAN TRANSIT.

BY W. JONES CUTHBERTSON, MEMBER OF THE TECHNICAL SOCIETY OF THE PACIFIC COAST.



[Read before the Autumnal Meeting of the Society, December 15, 1905.]

ALTHOUGH I am not a professional engineer, the subject of which I treat is so apropos at the present time that probably no apology is needed for bringing it before you, even under the adverse circumstance of its being treated by an amateur.

It is proposed to exhibit a method of running railroad traffic in public streets which I believe has not yet been sufficiently exploited, referring especially to San Francisco, to which it is peculiarly applicable.

Street railroads may be run on three different planes in relation to the ground level: Below the surface, on the surface and above the surface. This may be exhibited by vertical sections showing ways of arranging the common road and the railroad, the lines indicating the before-mentioned planes.

| (1) | (2) | (3) | (4) |
|---|---|---|---|
| o | o | railroad | common road |
| common road | common r'd & R.R. | common road | railroad |
| railroad | o | o | o |

(1) is an example of railroad beneath the surface of the ground.

(2) is an example of railroad and common road on the surface at the same level.

(3) is an example of railroad elevated above the surface.

(4) of railroad on the surface and common road above it.

1. Sewer.
2. Scavenger service tracks.
9. Subway walk.
11. Sewer manholes.
12. Water main.
13. Gas main.
14. Steam main.
15. Pneumatic tube.
16. Electric conduits and wires.
17. Rapid transit subway tracks.
18. Glass tile lighting railroad subway.
19. Ventilating grating for railroad subway.
20. Columns supporting high-level roadway.
21. Columns supporting high-level sidewalk.
23. Local car tracks.
24. Platforms.
25. Stairs or bridge connecting high- and low-level.
26. Roadways for freight.
27. Low-level sidewalk.
28. Glass tile lighting pipe subway.
30. Trusses supporting sidewalks.
31. Trusses supporting upper roadway.
37. High-level roadway.
38. High-level sidewalk.
39. Bridges.
43. Parapets around light areas.
45. Upper sidewalk lights.

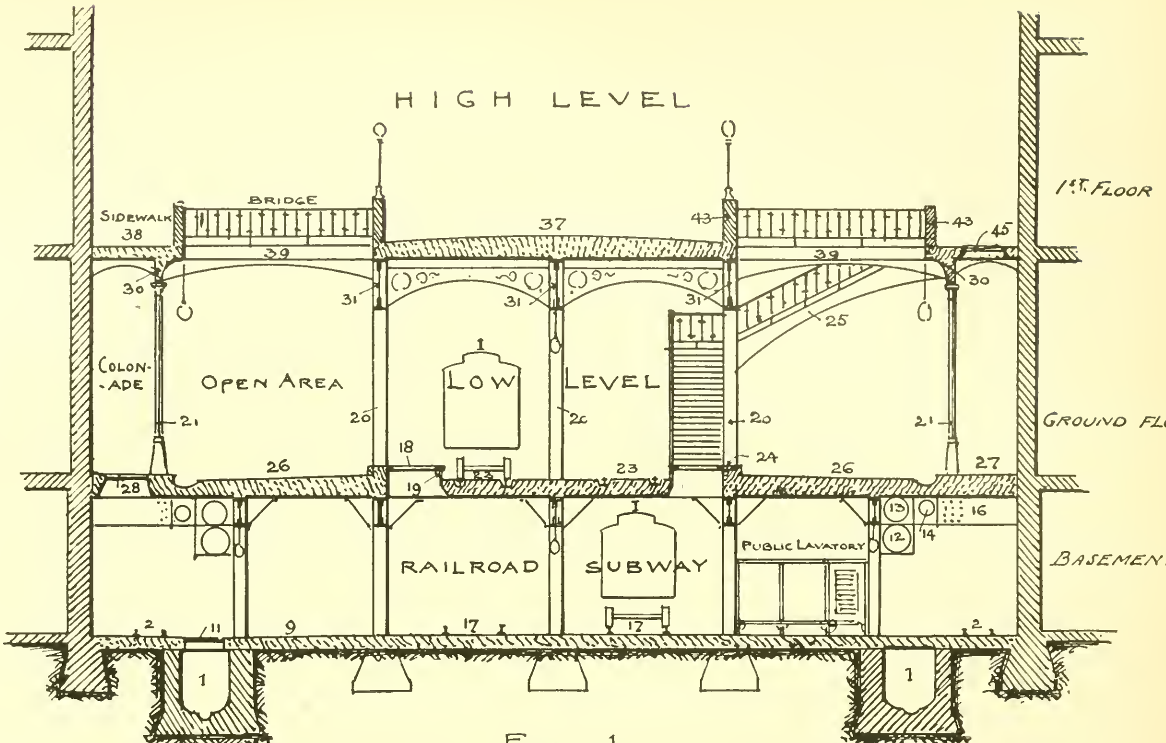
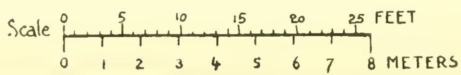



Fig - 1.

CROSS SECTION (X) OF STREET, SHOWING RAPID TRANSIT SUBWAY.

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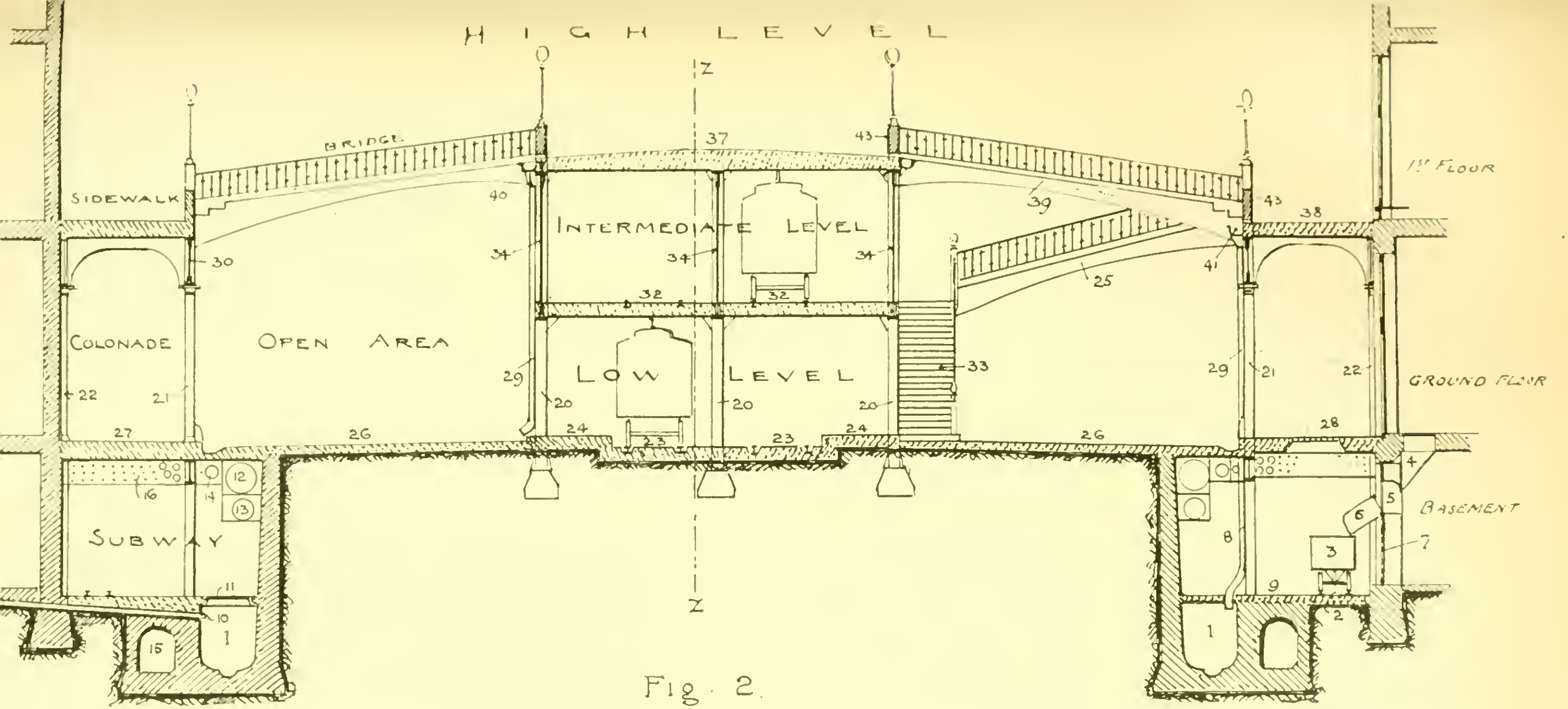


Fig. 2

CROSS SECTION (Y) OF STREET SHOWING ELEVATED RAPID TRANSIT R R

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3. Scavenger service dump wagon.
4. Refuse chute.
5. Refuse bin.
6. Same tipped, delivering into dump wagon.
7. Grille inclosure of basement.
8. Low-level rainwater pipe.
10. House drain.
22. Stanchions against wall of building.
29. Rainwater pipes from high-level.
32. Rapid transit elevated tracks.
33. Stairs to low level.
34. Trusses supporting rapid transit and carriage roads.
40. Gutters of high-level roadway.
41. Gutters of high-level sidewalk.

All these arrangements have been tried except (4), which is the subject of the present paper.

Before considering anything new, it is advisable to find out whether existing conditions are bad enough to warrant a change, and if so, whether this change will bring about something sufficiently superior to warrant its supersession of the old. Therefore, before going further, let us look at the systems now in use and see wherein they are objectionable.

Generally the objections to the systems now in use may be taken as follows:

1. Railroad below Ground.
   Cannot be used for local traffic.
   Costly.
   Unhealthy and unrecreative.
   Interfering with sewerage and pipage.
   Accidents intensified.

2. Railroad on the Surface and on Same Level with the Common Road.
   Cannot be used for rapid transit.
   Very dangerous.
   Inconvenient and therefore uneconomical for both railroad and other traffic.

3. Railroad Elevated above the Surface.
   Cannot be used for local traffic.
   Hideous.
   Annoying to residents on the route.
   Accidents intensified.

I believe that this indictment of our present means of municipal transit is sufficient to warrant an investigation of arrangement (4), which it is claimed will avoid all these objections.

To appreciate its comparison with the other examples, it will be well first to consider the practical method of carrying it out. Figs. 1 and 2 represent what might be called a two-storied street. It will be noticed that there are three horizontal divisions, the lowest being the subways for sewers, water and gas pipes, electric wires, steam pipes, pneumatic tubes and all the other carrying apparatus which are now necessary for our civic life; the middle one for the railroads and heavy traffic, which we shall call the low level or lower street; and the roadway above this, supported by posts, beams and arches for light travel

and promenading, which we shall call the high level or upper street.

Taking these in their order, we shall first consider

### The Subways.

These are located on each side of the street next to the building line.

The enclosing walls and the floor are made of concrete. Along the center line is built the channel for sewerage. The flow in the sewer is regulated by sluices at proper points so that the channel may be periodically flushed. Salt water is used during the rainy season, where obtainable. The subway patrol attends to this and all other matters in regard to watching, cleaning and keeping in repair the subways. On each side of the sewer are walks. The pipes, tubes and conduits are carried by iron brackets or shelves fastened to the ceiling. On the walk nearest the houses is the narrow track for the scavenger trains hereafter mentioned.

The size of the subway varies in accordance with the demands made upon it. Its walls are lined with glazed white tile. The roof is supported on steel beams running from wall to wall, filled in with concrete, glass tiles forming the sidewalk above, as is shown in the illustration; the rest of the subway roof forms part of the road and its gutter. The rain water from the high level is carried from a catch basin through iron pipes to the low level, from which they empty directly into the sewer below as shown (8).

In the inner wall of the subway are ensconced the ash bins, one to each house, projecting towards the basements, into which is delivered all the solid waste matter of the houses. These bins are made to tip outwards when desired, and the contents are thrown into the dump wagons (shown in Fig. 2) drawn by electric motors, which empty these bins and carry the waste to the incinerators. Stairs are placed at each corner of the main streets and at the railroad platforms, so that pedestrians and passengers may descend to the subway and cross under the street, and also get to the public lavatories, which are placed adjacent to the subway where deemed necessary.

### The Railroad Subway (see Fig. 1).

The subway for the rapid transit railroads is to run on the cross streets and is built in the same manner as the sewer subway. The platforms of the road above are floored with glass tile and

their risers are made of metal gratings, admitting light and ventilation through the ceiling of the railroad subway. In the center of this subway are arranged the steel columns which support the ceiling and which are carried up to the high-level roadway, which they support in the same manner.

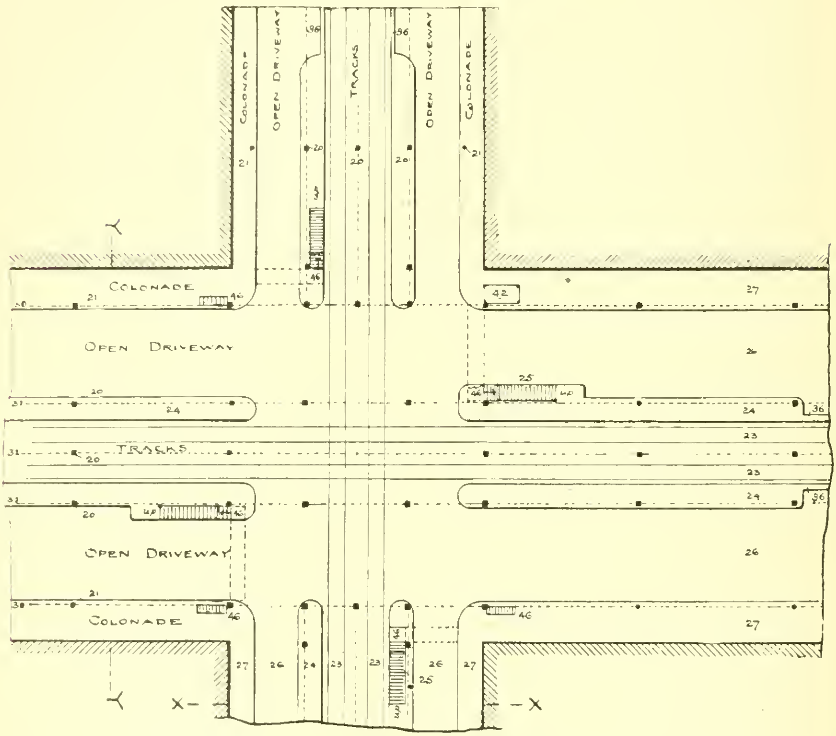


Fig. 4. Plan of Low Level Streets

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20. Columns supporting high-level roadway.
21. Columns supporting high-level sidewalk.
23. Local car tracks.
24. Platforms.
25. Stairs or bridge connecting high- and low-level.
26. Roadways for freight.
27. Low-level sidewalk.
30. Trusses supporting sidewalks.
31. Trusses supporting upper roadway.
32. Rapid transit elevated tracks.
36. Curbs to prevent teams passing over tracks.
42. Elevator.
46. Stairs to subway for passengers to cross under road and to public lavatory.

## The Low Level.

The low level corresponds with the present street level.

In the center run the local cars, picking up and setting down passengers at any place they may desire. Their tracks run alongside the longitudinal platforms or pathways running between the tracks and the vehicular traffic and acting as a

preventive to teams crossing the tracks except at certain intervals and as platforms for passengers of the local cars.

On those streets where rapid transit cars run, the rapid transit tracks, except where before mentioned, are placed over the local tracks and between them and the carriage road above, as shown in Fig. 2. In consequence, however, of the gain in speed of the local cars, arising from their tracks being freed from all other traffic, rapid transit railroads will be required to a very limited extent.

The space of the street outside the local tracks is a roadway provided with longitudinal granite trams, devoted to heavy teaming and for loading and unloading into the ground stories.

To epitomize, the arrangement of the low-level street from center line out is as follows:

1. The central row of columns (20).

2. Local trains, with rapid transit trains over, where used (23).

3. Intermediate platform (24).

4. Freight roadway and space for backing up and unloading goods (26).

5. Narrow sidewalk next to ground floor front of buildings, width depending on width of street (27).

## The High Level.

In the center is a roadway for light traffic and pleasure vehicles; then comes an open light and air area for the low level, railed in; finally the sidewalk, for promenaders and for those who desire to look at the shop displays, as on this level are the main store fronts.

Frequent bridges connect the roadway with the sidewalk, and provision is made at each intersection of sidewalks for people to get from one level to the other. This is effected by stairways or inclined planes running from the sidewalks at the crossings of the streets to the lower platforms, as shown in plan on Figs. 4, 5 and 6.

A public elevator will run from the high to the low level at these crossings. At intermediate places the public desiring to go from one level to another will use the elevators of the stores, which the shopkeepers will gladly allow as a means of publicity.

To avoid any level crossings on the rapid transit tracks, those on streets running in one direction are placed over the ordinary street cars, while those running in the other direction

are placed in a subway. These latter rapid transit cars will be those of cross-town lines, such as the Filmore, Larkin and Kearny street lines in San Francisco. The sewers are low

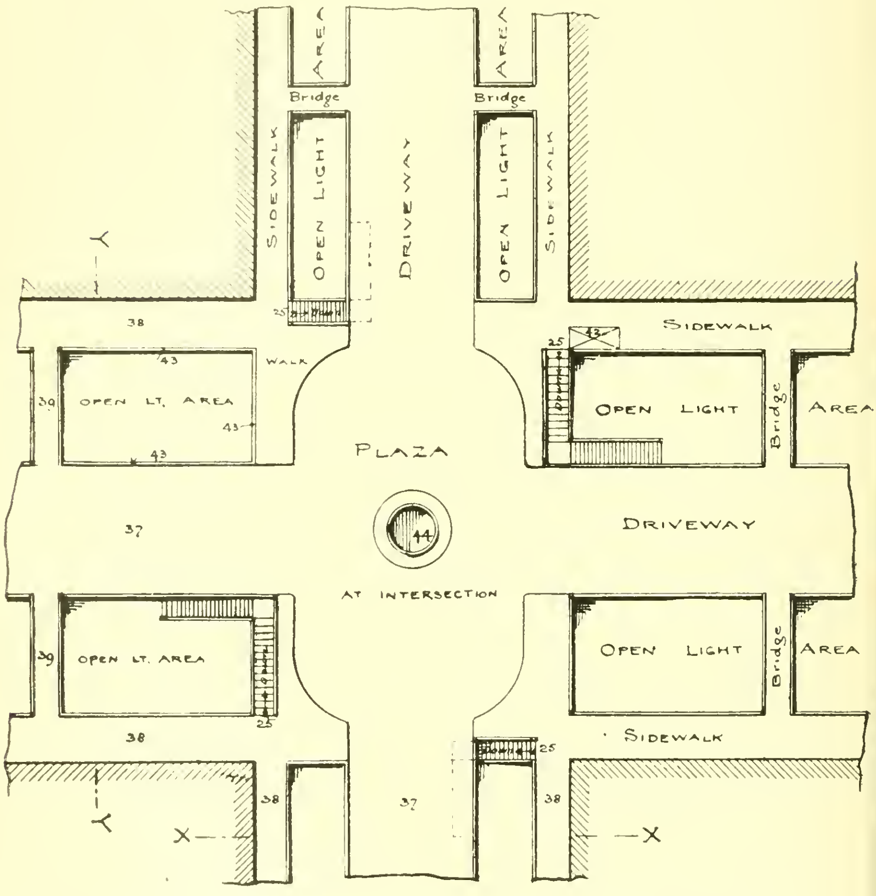


Fig 5. _ Plan of High Level Streets

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25. Stairs or bridge connecting high- and low-level.
37. High-level roadway.
38. High-level sidewalk.
30. Bridges.
42. Elevator.
43. Parapets around light areas.
44. Central light well and Island of Plaza.

enough to run under these railroad subways where crossing them, and the other pipes generally run over them.

One of the stations of the rapid transit railroad placed on the intermediate level is shown in Fig. 6 and its connections by

stairs with the high and low levels. Its connection with the local cars of cross streets, in which case the platform will be in the middle of the street, is also shown. In fact, in all narrow streets the platform between the tracks in the center of the

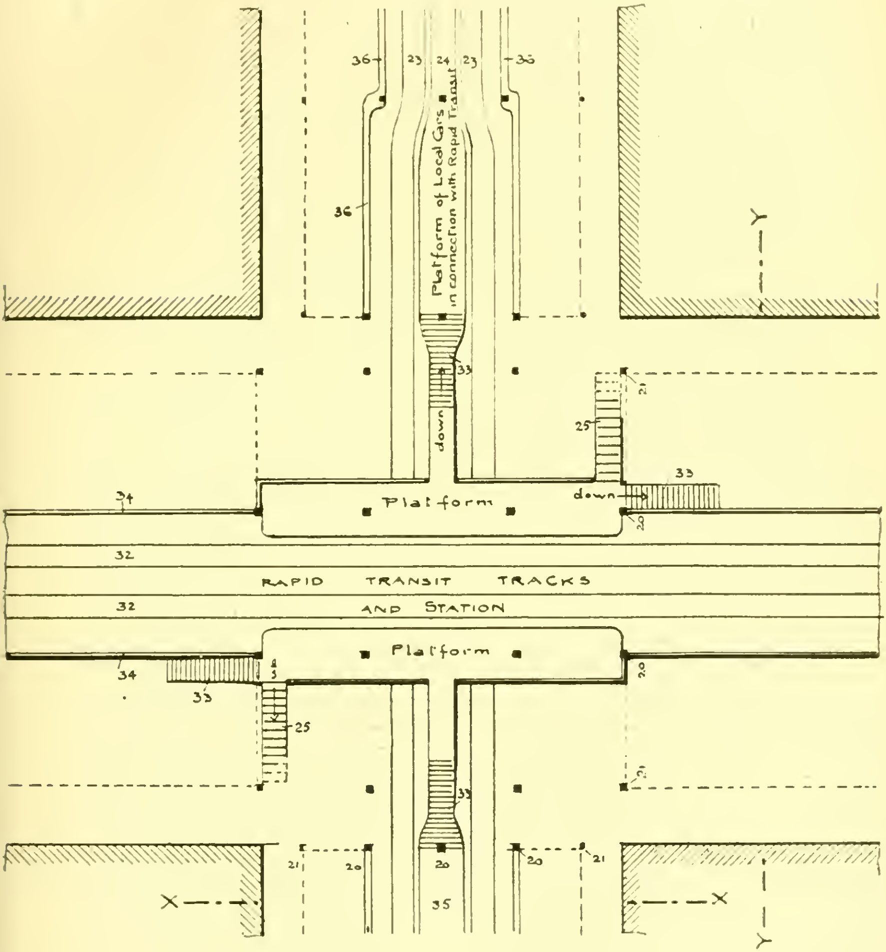


Fig. 6. Plan of Intermediate Level

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20. Columns supporting high-level roadway.
21. Columns supporting high-level sidewalk.
23. Local car tracks.
24. Platforms.
25. Stairs or bridge connecting high- and low-level.
32. Rapid transit elevated tracks.
33. Stairs to low level.
34. Trusses supporting rapid transit and carriage roads.
35. Platform of local cars at rapid transit station.
36. Curbs to prevent teams passing over tracks.

street will be preferable to the arrangement shown in Fig. 4, as it will allow more space for teams.

Inclined roadways for the use of vehicular traffic connect the high and low levels at convenient intervals. On those streets where there are elevated rapid transit railroads, these connecting roads or inclines will naturally be of somewhat greater length than required for streets where no rapid transit railroads run, due to the greater height of the high-level road. In hilly cities, such as San Francisco, however, the configuration is such that advantage can be taken of the adjacent risings of grade for these connecting roadways, as we shall describe later on.

### Superstructure Construction.

The superstructure consists of rows of columns of steel or other material, which may be from 30 to 50 ft. apart, supporting lattice girders or arches as shown on the longitudinal section, Fig. 3. On these rest the cross steel beams carrying corrugated arches filled in with concrete or any other approved system for the roadbed and sidewalks of the high-level street and for the rapid transit railroad where used.

Bracing and tying this structure are the steel arched or suspended bridges, which connect, at intervals of about 100 ft., the roadway and the sidewalks. They have ornamental railings and newels forming lamp-posts and are about 6 ft. wide. The structure is strongly anchored to stanchions built into the walls of the buildings on each side, thus forming a rigid whole.

In those streets where the rapid transit trains run above the locals, the upper roadway is higher than the sidewalks, thus giving the bridges an incline and giving height for both sets of cars between the high and low levels. (See Fig. 2.)

This brief description gives a sufficient idea of the construction for our purpose, and we will pass on to the next subject.

### A Comparison of This System with the Ones now in Use.

Taking up the subject systematically we shall compare them in regard to the following:

1. Public safety.
2. Health and recreation.
3. Economy and convenience.
4. Artistic effect.

#### 1. PUBLIC SAFETY.

The present mode wherein car traffic and all other traffic are together on one roadway is a menace to public safety. The

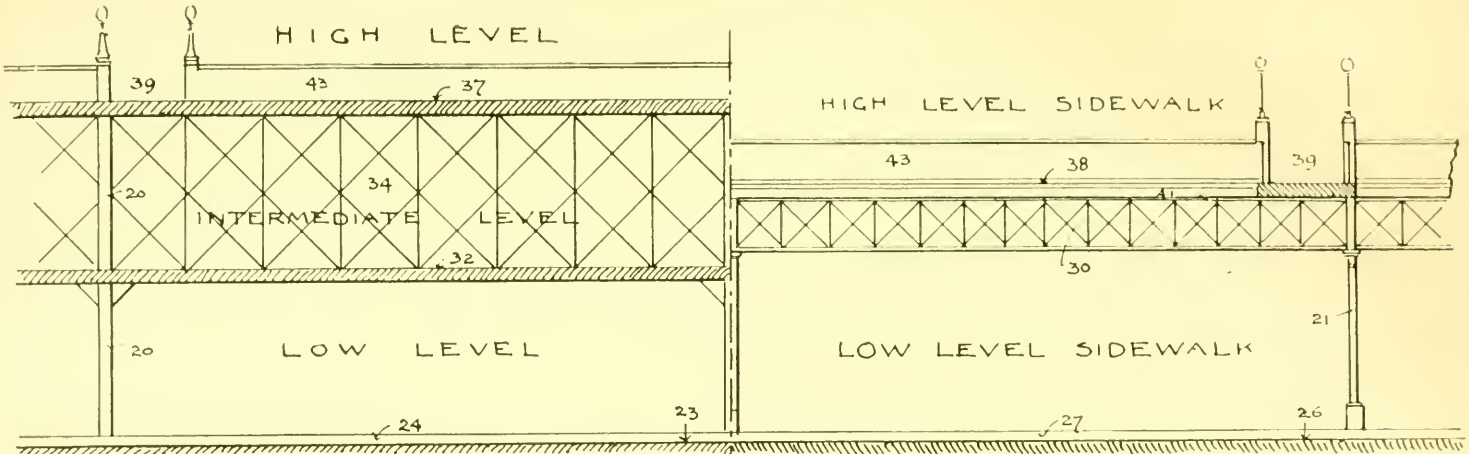


Fig 3

SECTION ALONG CENTRE LINE OF A STREET WHEREIN ELEVATED RAPID TRANSIT R.R. IS (Z)

ELEVATION OF HIGH LEVEL SIDEWALK



20. Columns supporting high-level roadway.
21. Columns supporting high-level sidewalk.
23. Local car tracks.
24. Platforms.
26. Roadways for freight.
27. Low-level sidewalk.
30. Trusses supporting sidewalks.
32. Rapid transit elevated tracks.
34. Trusses supporting rapid transit and carriage roads.
37. High-level roadway.
38. High-level sidewalk.
39. Bridges.
41. Gutters of high-level sidewalk.
43. Parapets around light areas.

dangers of a trip through the streets are so familiar that I will but briefly allude to them.

We have a daily roster of people crushed, maimed, ground to pieces or otherwise damaged by the street cars and by other vehicles. In our streets railroad cars fly by in opposite directions, while intermixed therewith are vehicles of all descriptions, some drawn by horses, others driven by man-power and others by gasoline or electricity. It is no wonder that those who are not thoroughly used to this pandemonium can but with difficulty steer themselves amongst these multitudinous moving things, and that even those who are brought up amongst them cannot for a moment relax vigilance without risk of their lives, so that, notwithsanding the regulation of the traffic by the police and other safeguards adopted, accidents to pedestrians attributable to the congested and mixed traffic of the streets are inevitable and frequent.

Accidents to vehicles and their occupants are also frequent. They are attributable to the following classes: Collisions between the cars themselves; between cars and other vehicles (due to the car lines being used by both); collisions among other vehicles (due to congestion of traffic and slow and rapid vehicles using the same road; also to the bad state of the roadbed due to the frequent excavations necessary to get at underground pipes); and collisions with these excavations and the detritus therefrom.

Amongst other classes of accidents are those due to the fall of live electric wires from the overhead lines.

Now let us see how these accidents are practically eliminated by the system under discussion.

As to pedestrians, one on the upper street wishing to cross the road or take a car need not cross the upper road (which is used by fast teams) at all, but may descend the stairs to the low-level intermediate platforms, whence he may take a car or cross the lower road (which is used for slow teaming) to the opposite sidewalk; and then, if he wish, take an elevator to the upper sidewalk. The vehicles on each side of the lower street being allowed to go in one direction only, and the car tracks between the platforms being used by cars only, the danger of crossing is practically *nil*. Fast-traveling automobiles are allowed only on the upper road; freight autos on the lower.

Coming to accidents to the vehicular travel, which are now of almost daily occurrence, no diminution can be expected until the introduction of some such system as that now before you,

by which the heavy drays and slow traffic are kept in the lower street and the car tracks devoted to their own use; the side of the street located on one side of the car tracks being devoted to up traffic and the other side to down traffic.

As to accidents due to the tearing up of the streets, by the adoption of the subway system shown they will be done away with entirely.

Accidents from electricity will be considerably reduced, as the power lines for the electric cars are kept within the space under the high-level roadway occupied by said cars, while the remainder of the street will be clear of all wires, they being carried in the subway.

In regard to underground and elevated railroads, indicated as numbers (1) and (3) on the diagram of the introductory paragraph, there is no doubt the accidents happening on either of these systems are intensified by the facts of one being in the darkness and cramped space of a tube or tunnel and of the other being suspended in the air.

As used in the new system, although the rapid transit railroad is elevated, its height from the normal grade is but moderate, and the subways for the cross-town rapid transit are close to the surface and thoroughly lighted in their whole courses by the sidewalk lights on the platforms of the local car lines above.

### 2. HEALTH AND RECREATION.

People traveling in underground tunnels cannot arrive at their destination in such fine condition as those who travel in the open air and sunlight, and the constant use of them finally deteriorates health. Now, in the plan herein described, the local and most of the rapid transit lines are above ground and are open to the air and sunlight, giving pure air at the same temperature as the normal air and the recreative effect of looking out upon lively sights and light and shade instead of upon the uninteresting walls of a subway. The discomfort of tubes is too well known to need description, and the heat evolved by the electricity adds to it, and there seems so far no way of mitigating it.

Again, not only to the travelers, but to the workers in stores, the conditions under the new plan will be more favorable to health than under the present. At present, basements are used in connection with many stores by work people who remain there, not only occasionally, but all the time during working hours. These are underground, depending for their light on

the sidewalk lights. In the new plan the ground floor takes the place of a basement, with the benefit of direct light and air from the street. To be sure, the sidewalk above and the upper roadway cut off a part of the light, but the large open spaces in the upper street forming light areas serve to give a bountiful supply of light and fresh air. Then the cellars, which will correspond with the present basements, will be used only for storage.

In the matter of drainage, under the new plan the draining of a city can be done with the minimum of unhealthfulness and disagreeableness, for the sewage is carried in channels open to inspection, which can be kept constantly clean and unobstructed. Also, the sidedrains from the buildings can be cleaned out periodically with but little trouble and expense, there being a movable cover in the sewer at every connection.

With the light and ventilation obtained, a promenade in the subways could be made without meeting anything more disagreeable or unhealthful than during a walk on the surface of the streets now. Loss of life to sewermen by being washed away and drowned or suffocated (of which a case in point has but lately happened in San Francisco and another in London but shortly previous, in which latter case three men were washed away by a flood of storm water and two of them drowned) will be eliminated.

### 3. ECONOMY, INCLUDING CONVENIENCE.

When the citizen of twenty-five years hence shall look back at the municipal transportation of the commencement of the twentieth century, he will surely be astonished at the great sacrifice of convenience and of time made by the citizen of this epoch, due to its haphazard street plan, and will wonder why conditions so far behind the times could have been tolerated. We will enumerate some of these inconveniences, and will show how they will be abolished or mitigated under the new plan.

*Traffic.* — The street car tracks are now used by cars and ordinary vehicles in common. This leads to much delay in travel by vehicles breaking down on the tracks and by heavily laden and slow teams getting in front of the cars. This is done away with by the new plan.

Other traffic will also be facilitated. Delays caused by blockades, now so frequent, will be things of the past in consequence of so much of the traffic being carried by the high-level street.

On the surface of the present-day roadway are the manholes and handholes for getting at the sewers, cables of the cable cars, electric wire conduits, etc., so that it is studded with the plates covering these, causing, as wheel traffic rolls over them, an addition to the already deafening noises of the street. Obstructions are caused by the many breakings up of the roadbed necessitated by the lack of a subway, and by building materials required for the erection of new buildings. Under the new plan the latter will be placed on platforms over the light areas of the high-level street, and all the other obstructions, being unnecessary, will be removed from the roadways.

Among other things, the scavenger wagon, the source of so much discomfort to our olfactory nerves, and the keeping on hand quantities of decaying matter until the arrival of said wagon, so deleterious to health, will be abolished, the subway scavenger train before described taking their places.

*Promenading.* — In consequence of the transaction of all rough work on the low level, the high-level pavement is unencumbered by the many obstructions in the way of the present-day pedestrian: the rolling of barrels from drays into cellars, piles of merchandise waiting to be shipped or in process of shipment, porters with burdens, the rush of messenger boys, newsboys and of car-catchers, sidewalk elevators and trap doors, steps descending into basements, valves of the water-works, fire-plugs, telegraph poles, signs, etc. By the eliminating of all these obstructions a promenade through the streets of the new régime will be agreeable and peaceful and free from all the inconveniences now encountered. Besides, one can promenade in wet weather as well as in dry, for the high-level sidewalks form colonnades below under which people can pass dryshod and dryclothed.

Not only are the inconveniences before mentioned done away with, and their attendant waste, but direct economies are gained by the new system.

*Cost.* — Underground work being more expensive than work in the open, the first cost of an underground railroad is considerably more than the building an ordinary road overground as shown. Again, making comparison with an elevated railroad, the cost of an overhead carriage road is no more, if as great.

The cost of building an underground railroad in San Francisco will be further increased, in the lower part of the city, by reason of its being below water level and of its excavation being all in sand or soft mud.

*Maintenance.* — After the subways are built for the pipes, much economy will be gained in the installation of new work and in making repairs, which would require no digging from the street and no disadvantage to the workmen from working in the midst of traffic or in a cramped place. The house drains, for example, go directly into the subway sewer close to the property line, doing away with digging trenches in the streets and laying side sewers, those bugbears of the small property owner under the present régime.

There are also gains in indirect economy by the adoption of the new system, such as eliminating the following:

The interference to traffic caused by work on the surface.

The interference with the shipping of merchandise caused by the congested condition of the streets, the two-tiered streets allowing the freight handling on the lower and the retail selling on the upper level to be carried on without obstruction from other traffic.

The waste of time and patience caused by lack of proper car service.

Expenses and loss of time from impaired health caused by bad sewerage system and other bad conditions and from maimed bodies and burial expenses caused by street accidents.

Damage to business during the building of an underground railroad.

Damage done by the flooding of basements of stores and the consequent destruction of valuable goods by the obstruction of the sewers preventing the sufficiently rapid outlet of storm waters. In the new plan double capacity is obtained by having a sewer on each side of the street, as well as greater facilities for cleaning.

### 4. ARTISTIC EFFECT.

The opportunities for artistic effect are unquestionably greater in the proposed arrangement. The upper streets, from which are banished the disagreeable sights which are wont to meet us in our present streets, will form vistas unequaled, and every part of them will lend itself to some artistic effect.

The parapets and ornamental railings bounding the roadway and sidewalks, the lines of the bridges connecting the same, and the pedestals at their junctions forming coignes for sculpture and lamps, with occasional recesses for seats from which may be viewed the traffic below, all will form an interesting and picturesque study, as well as a monumental *ensemble*. Opposite

public and important buildings bays will be formed in the upper roadway for waiting vehicles. Municipal regulations as to heights of buildings preventing hideous skyscrapers from marring the skyline will add still more to the beauty of these streets and will allow the life-giving sun to send its rays upon this enchanting scene.

The contrast between the foregoing picture and that of an elevated railroad (both to users of the street and of the windows of the abutting houses), with its darkening of the street below and its rumbling noise, is so strong that comment is unnecessary.

## Objections.

Having now compared this two-storied street arrangement with the other street arrangements and pointed out its advantages, it is time to take a glance at the objections that may be raised against it.

*First.* — An objection, at first sight, is the taking from the property owner the private use of the sub-sidewalk space, although the same really belongs to the public. Any space, however, the property owner may lose is counterbalanced by the extra basement space he gains by the raising of the street to the high level, which saves him the expensive delving into the bowels of the earth which is now so common.

In his cellar he will obtain the same amount of light from the subway as he does now from his sidewalk lights. There is also a saving by having all the service mains close by and handy to his building.

*Second.* — Objection might be made because of the difficulty experienced in the connection of high and low levels so that vehicles may go from one to the other.

In hilly San Francisco, or in any other hilly city, the occasion of this objection is really a benefit; for as the two-storied roads will be used chiefly on the business streets, which are always the valley streets, a connecting road will run level from the upper road until it strikes the rise of the street below and there becomes merged into it. So that a vehicle traveling on the upper system of roads when it follows the connecting road and reaches the normal or ground level will have saved the traction of raising itself the height of the difference between the high and low levels.

This subject will be exemplified when we consider its particular application to San Francisco.

*Third.* — Objection to the expense of adapting the present buildings to the new arrangement.

As is the case with the introduction of all new things, there will be some trouble and expense in adapting the present conditions to those appertaining to the new plan. Store fronts will have to be altered and entrances made from the upper sidewalk. This will not be such a great undertaking as it may appear at first sight. All of the large stores already have second-story show windows, which will come in for the new street. In San Francisco, especially, all the modern buildings, except a very few, are yet to be built on Market and other streets. If this system is adopted at once, all new buildings will conform to the appropriate levels and no extra expense will be entailed; the expense of changing those already built will easily be recouped by the benefit of having two stories of show windows accessible from the street or, in other cases, of two stories of street floor offices and by the numerous other accruing benefits previously described. For example, on Montgomery Street, San Francisco, the capacity for street-floor offices will be doubled, with a corresponding increase in rents.

*Fourth.* — It might be objected that the lower street will be dark.

With the large light wells obtainable on the wider streets, it will assuredly not be so to any extent. In the case of narrow streets the upper sidewalks will be made of prism lights, which will flood the space below with all the light needed.

### Application to San Francisco.

We will apply this plan to San Francisco, the city in which we are more particularly interested; firstly, in regard to the street railroad system, and secondly as regards the ordinary carriage road.

It is premised that all the work for these undertakings will be done by the city, and that all the new car lines will be run by the city, which are on the lines of modern ideas.

To elucidate to those who are not familiar with San Francisco points made in this paper, I will state briefly that, outside of flats around the Bayshore, this city consists of hills and valleys. Market Street is the chief street, running diagonally across the city, dividing it into north and south parts. The streets on the north side run into it at about an angle of 45 degrees, while the streets on the south of it in the business part of the city run parallel and at right angles to it.

*Rapid Transit Railroads.* — The first of these would naturally be the one on Market Street. This line will answer two purposes: below Geary Street to the ferry at the foot of Market Street it will act as a feeder to the new Municipal Geary Street Railroad, so that the latter may have an outlet to the said ferry, and it will give quick service to all those lines running into Market Street on both sides. It will make the people a competitor to some extent of the present street railroad company which now has practically a monopoly of all the street-car traffic.

Other rapid transit roads would be built as wanted; but their routes will have to be decided upon in the first instance, so that the height of the upper carriage road may be regulated to suit.

*Surface Railroads.* — The present surface railroads will remain as they are, excepting that the motive power will be changed to electricity where practicable. The cars being hidden under the upper street the objection to overhead electric wires will not exist.

The loop at the foot of Market Street will naturally be adopted, but this will be combined with the overhead street and will form a grand peristyle effect in connection with the upper hall of the Ferry building.

*The Upper Roadway.* — Now let us turn to the upper roadway, used for ordinary traffic.

Starting from the Bay, the main road will follow Market Street to its present end. It will strike the top of the range of hills enclosing Eureka Valley, which will be graded down sufficiently to allow the lower road to keep its level. Then extending Market Street across Eureka Valley, it will be carried on a viaduct to the Corbett Road, into which it will be merged, and will continue around Twin Peaks to the ocean, thus forming a continuous and unobstructed driveway from bay to ocean. At some future time Twin Peaks will be tunneled for a car line and have a cable car running to the park at the top; but the scenic driveway will continue to be the Corbett Road, the parking of which on its low side, so as to allow an unobstructed view of the magnificent panorama, should be done.

From the main artery of Market Street let us take a rapid glance at some of its branches.

On Montgomery Street an upper driveway is an absolute necessity, as is recognized by any one who has witnessed the present continual blockades of that street. This will stop at Telegraph Hill, with spurs on Pine Street and other convenient

streets running to the east slope of "Nob Hill," whence descents will be made to the lower level. This will help out the scheme of Engineer Parsons for the improvement of that slope.

Other streets on which connection with the low level can well be made are Grant Avenue and Golden Gate Avenue, both of which rise enough to allow the spur road to reach them on or about on the level; City Hall Square, where it can be run to the main floor of that building; Van Ness Avenue, where it will be continued out to the new Park Panhandle, in the making of which it will save some cutting and filling.

At Haight Street a spur will be run on to the Haight Street hill and thus descend to Valencia Street and the Mission.

At Dolores Street it will be on a level with that street and also with the new boulevard proposed to run from the junction of Dolores and Market streets to the present Park Panhandle, designed by me some years ago and adopted by the Association for the Improvement and Adornment of San Francisco in its map of the improvement of that city. This boulevard will make a continuous level driveway from bay to park, and through it to the ocean, along the beach to the road before described, around Twin Peaks, thus giving the most varied interurban drive to be found anywhere. Time will not allow me to point out the possibilities of this scheme, which will make of San Francisco the most magnificent city in the world. From this improvement we shall have a direct return at once in carfares on the municipal railroads.

## Summary.

Although this is but a rough sketch of the scheme, I believe sufficient has been indicated to allow of a judgment upon its feasibility, and I conclude its description by a summary of its claims.

1. The substitution of light and airy car lines for dark and ill-ventilated tunnels.

2. Covered ways for travel in inclement weather.

3. All the sewers, pipes and wires accessible without tearing up the streets.

4. An unseen and unobjectionable scavenger service.

5. A swift, convenient and safe method of car service.

6. Basement above ground, doing away with underground dark and damp cellars.

7. Two stories of street store fronts.

8. A roadway without car tracks and yet a street with the convenience of car service.

9. Clearance from the promenade of all obstructions due to commerce or otherwise, which are hereby relegated to the lower regions.

10. Economy, both in construction and service.

11. Grander artistic effects than are offered by the ordinary streets, or by any other scheme so far devised.

## Conclusion.

Now, as is generally known, California is the country of great things, — material, physical and mental, and possibly psychical, — great in trees, great in physical humanity and great in ideas and inventions. Why not great in civics?

Because we have not relied sufficiently upon ourselves in that case, but have gone to strangers for advice. This shows that Californians are great likewise in modesty. No doubt it is well to hear and see what other places are doing and to receive suggestions from them — sometimes as to what to avoid — but whenever we want to do a thing right we must do it ourselves.

The ideas obtainable from the experience of Chicago New York and other cities as to the beautification and improvenent of our Californian metropolis are inapplicable to it. It is a city *sui generis*, understood only by its own children, who know and respect most of its idiosyncracies, and therefore the ideas presented here by a Californian are not to be considered unavailable because found unsuitable elsewhere, but deserve full investigation.

As before, San Francisco has surmounted difficulties in its own way; for example, in its introduction of the cable-car system; so will it solve the metropolitan transit problem as successfully.

As generally, so far, California has been in the front rank in great, useful and beautiful things, why should it not inaugurate a great, useful and beautiful system of civic intercommunication?

Note by Author. This paper was read previously to the catastrophe that has visited San Francisco. Some of the remarks are therefore a little out of date. The introduction of the scheme into that city, however, is now much simplified and the arrangement of buildings to suit it can now be made from the ground up with no extra expense.

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[Note. Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by October 1, 1906, for publication in a subsequent number of the Journal.]

## THE POLLUTION OF THE TIDAL WATERS OF NEW YORK CITY AND VICINITY.

By George A. Soper, Member of the Boston Society of Civil Engineers.

[Read before the Sanitary Section, March 7, 1906.]

The studies which we are about to consider are largely the outcome of a proposal to collect the sewage of a populous community in New Jersey and empty it without purification into the center of New York Bay. The project was that of the Passaic Valley Sewerage Commission and the object was to relieve the Passaic River of the excessive pollution which had made it a public nuisance.

The quantity of sewage which it was proposed to dispose of in this way was ultimately to be 345 830 000 gal. of house and factory waste per 24 hr. This sewage was to be continually discharged at a depth of 40 ft. below the surface of the bay, in the main channel, at a point about three quarters of a mile northeast of Robbin's Reef Light. This point is about the geographical center of the upper bay, or land-locked portion of New York Harbor.

The subject was brought to the attention of the New York Legislature in 1903 and a law was passed on May 11 of that year entitled, "An act to authorize the appointment by the Governor of a commission to investigate certain threatened pollution of the waters of New York Bay and to make an appropriation for the expenses of such commission." The commission was promptly appointed and assumed its duties. It consisted of Daniel Lewis, commissioner of health of the state of New York; Olin H. Landreth, professor of civil engineering, Union College; Myron S. Falk, consulting engineer; Louis L. Tribus, commissioner of public works of the borough of Richmond, New York, and George A. Soper, consulting sanitary engineer.

The first report of the commission was made to Governor Frank Wayland Higgins, March 31, 1905. It was published in the following autumn and is now out of print.

A second and final report will probably be made within a few weeks.* The commission will go out of existence by statute in April, 1906.

The first report of the New York Bay Pollution Commission

* The second and final report was submitted April, 1906.

made objection to the project of the Passaic Valley Sewerage Commission and, in fact, to the present policy of the unrestricted emptying of crude sewage into the tidal waters in the vicinity of the metropolis wherever that policy was followed. New York City was regarded as the principal offender, as matters stood. To that municipality, most of the sewage pollution of the bay and neighboring waters was due. Sewers as large, if not larger, than those contemplated by the Passaic Valley Sewerage Commission were under construction and in contemplation by New York City, and if this method of disposal was not prohibited, it seemed only a question of time when a nuisance as great if not greater than that which would probably result from the New Jersey project would be produced. How to dispose of sewage in the future in the vicinity of New York was considered a very serious problem and one upon whose early and proper solution depended the welfare of all the communities in this vicinity. It was desirable that the question should be studied exhaustively. The commission recommended that the two states of New Jersey and New York should appoint metropolitan sewerage commissions which should act together in investigating the best means of exercising proper control over sewerage questions in this vicinity in the future.

In the following paper, no attempt will be made to present a brief against the state of New Jersey or any part of it. This would be unnecessary even if my inclination suggested it. The Court of Errors and Appeals of New Jersey on March 6, 1905, declared unconstitutional the act under which the Passaic Valley Sewerage Commission proceeded, because of the method provided for levying taxes to meet the cost of construction and maintenance. The difficulty so presented has not yet been overcome. Furthermore, by an old and tested agreement with the state of New Jersey, the state of New York has jurisdiction over the waters of the whole bay for police and sanitary purposes and could exercise this right of protection if it was thought desirable to do so.

My object is to invite you to consider the interests of the Metropolitan District as a whole, without respect to state or municipal boundaries and to discuss the following problem from a strictly sanitary standpoint: Has or has not the time arrived when considerations of future economy, no less than the interests of public health and comfort, require that a comprehensive plan or policy be adopted for future sewage disposal for the New York Metropolitan District?

## Geography and Other Peculiarities of the New York Metropolitan District.

A glance at a map of New York and vicinity shows that it is peculiarly situated with respect to its adjacent tidal waters. Considering a circle with a radius of twenty miles, which just includes the extreme northern and southern limits of the city, it is seen that about one third of the surface is water and two thirds land. Bays, straits and rivers intersect it in every direction. New York City alone has 444 miles of water front. The center of this circle is the center of densest population. Here the water courses seem to come to a focus like spokes at the hub of a wheel. There are acres of tenements on Manhattan Island near this center, where there are over a thousand people to the acre. If the rest of New York City were as thickly populated, it would contain more than the combined population of the United States, France, Germany and European Russia.

The actual population, as given recently by the Census Bureau of the United States Department of Commerce and Labor and the Secretary of State of New York, is as follows:

| | |
|---|---|
| New York City | 4 014 304 |

Within a circle of twenty miles radius of the New York City Hall, in 1905:

| | |
|---|---|
| New York State | 4 174 392 |
| New Jersey | 1 250 311 |
| Total | 5 424 703 |

The increase in population has been very rapid, as is well shown by the following data which cover the same area as the present city of New York:

| | | | |
|---|---|---|---|
| Population in 1790 | 49 401 | | |
| 1850 | 696 115 | — an increase of | 1 309.1 per cent. |
| 1890 | 2 507 414 | — an increase of | 260 per cent. |
| 1900 | 3 437 202 | — an increase of | 37.1 per cent. |
| 1905 | 5 014 304 | — an increase of | 16.8 per cent. |

The rate of increase in the Metropolitan District as a whole, has been 17% in the last five years. At this rate the population will be more than 10 000 000 in 1930.

The tidal waters of New York are not only great highways of commerce but they play an ever increasing part in the life, health and pleasures of the people. An unpleasant odor from

the waters, even if noticeable only for a few hundred feet, would be inadmissible.

It is interesting to consider how intimately the life of the city is associated with its tidal waters.

The city has 7 325 260 acres of parks, a large number of which are on the water front. Riverside Drive is on the bank of the Hudson, the Speedway runs along the Harlem River, the Bay Ridge Parkway follows the shore of the upper bay and the Hudson County Boulevard, in New Jersey, skirts the crest of the Palisades.

On all festival occasions the city turns naturally to the Hudson and to the bay as to a great water park. These waters are the chosen place for the nation's greatest naval pageants. They are the home of a thousand pleasure boats from the palatial yacht of the multi-millionaire to the diminutive canoe.

To the poor of the city, the docks, and particularly those of the North and East rivers, are a place of welcome refuge in the hot nights of summer. For the accommodation of persons who cannot go to bathing beaches, or on other excursions across the harbor, the city has built recreation piers upon the water fronts of Manhattan and Brooklyn. The number of persons who visit these piers is surprisingly large. At a single one of them on the east side of the city, 8 000 entrances have been counted during a single evening.

Swimming baths float in the waters of the North and East rivers on the Manhattan and Brooklyn shores and accommodate upward of 3 500 000 bathers per season. At least one large inland swimming pool is supplied with water pumped from the bay.

A floating hospital carries 1 500 persons per day down the bay during summer weather and provides 7 000 baths supplied with water pumped directly from the harbor.

Within a few years floating hotels have made their appearance.

The use of salt water for fire service has been decided on to protect property against conflagration. By this plan pumping stations and separate systems of pipes will be constructed. To guard against corrosion, the pipes will be filled with fresh water when not needed. For fire purposes water from the bay and rivers will be pumped into them. One such plant has already been built at Coney Island. The others are about to be contracted for.

At present the sewage of the Metropolitan District is, for

the most part, disposed of in the crudest manner possible. It is emptied into the tidal waters without screening or other purification and at the nearest point which seems unlikely to produce a local nuisance. On Manhattan Island it was formerly customary to empty the sewers at the bulkhead lines, but this caused such offenses to sight and smell that the outfalls are now usually carried nearly to the outer ends of the piers. They usually empty at about the elevation of mean low water. In other parts of the water front the sewers generally empty at the bulkhead line.

In a number of instances this method of sewage disposal has led to serious difficulty. In a tributary stream of the East River, called Newtown Creek, odors from factory and household waste became so prevalent and offensive some years ago, that the state legislature was compelled to enact laws to restrict further contamination of this kind. The Gowanus Canal, in Brooklyn, is at present notorious for its stench. A tunnel has recently been contracted for at a cost of about $715 000 to carry water into the head of this canal from the bay. Pumps for this purpose will probably cost about $50 000 additional. The waters of parts of the East River and Kill von Kull are frequently covered with oily sleek which is offensive to both sight and smell. A number of sewage disposal plants intended to purify the sewage of small sections of the city in the outlying districts have been built, but usually with poor results.

The total amount of sewage which now enters the bay and tidal waters in the vicinity of New York has been estimated at 455 000 000 gal. per day.

### Bacterial Condition of the Water.

In the autumn of 1904 samples of water were taken from various points in New York Bay for bacterial and chemical analysis. About fifty samples in all were collected at points between the south end of Manhattan Island and Coney Island on the one hand and between the south end of Manhattan Island and Raritan Bay on the other. The colon bacillus was nearly always found, according to the presumptive test. There was a progressive reduction in the numbers of bacteria from Manhattan Island toward the ocean. The largest number which developed in gelatin was 50 000 and the smallest about 2 000.

The following table gives the average numbers of bacteria per cubic centimeter found in different parts of New York Bay.

Table Showing Numbers of Bacteria per Cubic Centimeter in the Water of New York Bay, October, 1904.

| | |
|---|---|
| Upper Bay, Middle of | 21 000 |
| Upper Bay, Staten Island Shore | 17 000 |
| Narrows | 10 000 |
| Lower Bay, Gravesend Bay | 7 000 |
| Lower Bay, off Coney Island | 4 000 |
| Lower Bay, off Staten Island shore | 2 000 |
| Mouth of Raritan River and Arthur Kill | 50 000 |

Most of the samples of water were taken to the Mount Prospect Laboratory, Brooklyn, and were analyzed, as a rule, within two hours of the time of collection. In the presumptive tests for coli, specimens of water 0.1 cu. cm., 1 cu. cm. and 10 cu. cm. were used. This work was done under the supervision of Mr. Daniel D. Jackson. In order to obtain a check on the results, some samples were sent to the Bender Hygienic Laboratory, Albany, N. Y., where they were examined under the supervision of Dr. R. M. Pearce.

In interpreting the results a positive presumptive test in each of the three samples was taken to indicate pollution; a negative result with 0.1 and a positive result with 1 and 10 was taken to be probable evidence of pollution; a negative result with 0.1 and 1 but a positive result with 10 was not regarded as sufficiently conclusive to warrant any opinion.

## Bacterial Condition of Shellfish.

As will be more fully explained beyond, the cultivation of oysters and clams is carried on extensively in the waters of New York Bay. Most of the oysters are taken from the southeast shore of Staten Island, but some shellfish, and especially clams, are grown in that portion of the lower harbor known as Gravesend Bay. Specimens of both kinds of shellfish were collected and examined by the presumptive test. They were opened with a sterilized knife and the liquid which was contained in their shells removed in portions of 0.1 cu. cm., 1 cu. cm. and 10 cu. cm. and mixed with fermentation broth in Smith tubes. The laboratory process was thereafter similar to that followed in the examinations of water. This method was not the most searching which might have been employed, for it did not detect bacteria which may have existed in the gills and alimentary tracts of the shellfish, but the results were considered sufficiently instructive. In general terms, the results supported the belief

that shellfish taken from polluted waters are themselves polluted and, conversely, that shellfish which have been grown in pure waters are uncontaminated. Yet the samples examined in this study did not always bear as much evidence of pollution as might be expected.

The oyster beds on the Staten Island shore lie between, but at considerable distances from, two great sources of danger, one the polluted water of the upper bay and the other the contaminated water from the mouth of the Raritan River and the Arthur Kill. The oysters which were freest from contamination came from the vicinity of Great Kills on the Staten Island shore and Swash Channel, points which are well removed from local sources of pollution and apparently beyond the reach of injurious matters from the cities. The oysters which were "drunk" or "fattened" in fresh water creeks always bore evidence of contamination.

## Chemical Condition of Water.

The chemical analyses which were made by the New York Bay Pollution Commission show that New York Harbor bears chemical evidence, both at ebb and flood tides, of pollution, especially the upper bay. The information at hand does not warrant the opinion that the water is everywhere and at all times badly contaminated, but the chemical evidence well supports the bacterial results in showing that traces of pollution can be found after the sewage has been allowed to commingle with the waters of the bay and traveled miles from its points of origin.

One of the most useful measures of pollution was the determination of nitrogen in the forms of free and albuminoid ammonia. The results of these chemical analyses were compared with results of examinations of uncontaminated sea water, drinking water and sewage, taken from Mr. H. W. Clark's report in the report of the Metropolitan Sewerage Commission upon a High Level Sewer for the Relief of the Charles and Neponset River Valleys, Boston, Mass., 1899, p. 91; the report by Mr. G. C. Whipple contained in the report of the Commission on an Additional Water Supply for the City of New York, 1903, p. 520; and the report of Mr. H. W. Clark contained in the report of the Committee on the Charles River Dam, Boston, 1903, p. 221. From these sources the following table was prepared:

TABLE SHOWING THE AMOUNT OF FREE AND ALBUMINOID AMMONIA IN SEA WATER, DRINKING WATER AND SEWAGE.

| Point of Collection. | Date. | Free Ammonia. | Albuminoid Ammonia. |
|---|---|---|---|
| Sea water | | 0.057 | 0.124 |
| Quincy Bay, Mass. | | 0.056 | 0.124 |
| Atlantic Ocean, 3 miles southeast of Sandy Hook Lightship | Feb. 27, 1903 | 0.064 | 0.076 |
| Off Boston Lightship | Nov. 11, 1902 | 0.012 | 0.068 |
| Sewage | | 45.4 | 7.5 |
| Good drinking water as high as, | | 0.013 | 0.16 |
| Hudson River at Poughkeepsie, | | 0.020 | 0.137 |

The studies of the New York Bay Pollution Commission show that the surface water of New York Bay contained at the time of examination about $2\frac{1}{4}$ times as much free ammonia and about $1\frac{1}{6}$ times as much albuminoid ammonia as sea water. It also had about $6\frac{1}{2}$ times as much free ammonia, but about the same amount of albuminoid ammonia as the Hudson River at Poughkeepsie. The samples were all taken near the surface.

The most polluted samples were taken near the Battery, the middle of the upper bay, the Narrows and near Coney Island.

By putting the figures into condensed form the following table has been prepared:

TABLE SHOWING THE AMOUNT OF FREE AMMONIA AND ALBUMINOID AMMONIA, IN PARTS PER MILLION, IN SEA WATER, HUDSON RIVER WATER AND THE WATER OF NEW YORK BAY.

| Point of Collection. | Free Ammonia. | Albuminoid Ammonia. |
|---|---|---|
| Upper Bay | 0.130 | 0.183—0.162—0.188 |
| Narrows | 0.120 | 0.120 |
| Lower Bay | 0.103 | 0.118 |
| Sea Water | 0.012 | 0.068 |
| Hudson River at Poughkeepsie | 0.020 | 0.137 |
| Sewage | 45.4 | 7.5 |

## THE EFFECTS OF TIDES, CURRENTS AND OTHER PURIFYING AGENCIES.

One of the surprising results of this investigation, as disclosed up to this point, was the fact that the tide had little

visible effect in eliminating the evidence of pollution. It had always been assumed that the sewage and other organic matters which were emptied into the harbor were immediately carried away by vast quantities of pure water which came from the sea, Long Island Sound and the Hudson River. But it was apparently found by the New York Bay Pollution Commission that there was not a great deal of difference between the quality of the water of the incoming and outgoing tides. In some cases the currents which flowed up the bay from the sea were more polluted than those which passed out. Apparently, in spite of the great tidal movement, particles of sewage which were not destroyed passed back and forth indefinitely in the bay and rivers in the neighborhood of their points of origin. The action of the tide seemed rather to cause a diffusion and distribution of the material than a mechanical and permanent removal of it. More light is needed as to the quality of the water, the action of currents and the flow of tides before this subject can be regarded as clearly understood.

The completeness of the diffusion which takes place apparently depends largely upon the swiftness and direction of the currents into which the sewage is discharged, the force and direction of the wind, the stage of the tide and the season of the year. As had been found at Boston, it seemed improbable that the sewage mixed with the water at all depths. It was more probable that it flowed about largely upon the surface.

The most reliable information which could be obtained from government sources as to the tidal discharge of New York Bay and fresh water discharge of the Hudson River was neither full nor accurate. The discharge of the Hudson seems not to have been estimated since the records given by the United States Coast Survey in its reports of 1858–1872. The following data are contained in these reports.

Table Showing the Discharge of the Hudson according to United States Coast Survey Reports.

| | |
|---|---|
| According to United States Coast Survey Report of 1858: | |
| Close of wet season — (June) | 6 038 million cu. ft. per tide |
| Close of dry season — (Sept.) | 3 360 million cu. ft. per tide |
| *Mean* | 4 699 million cu. ft. per tide |
| According to United States Coast Survey Report of 1872 | 4 511 million cu. ft. per tide |
| Tidal prism of bay, etc. | 5 330 million cu. ft. per tide |
| Average discharge of Hudson | 5 000 million cu. ft. per tide |
| Total seaward flow, *average* | 10 330 million cu. ft. per tide |

The tidal discharge of the East River, Hudson River, Kill von Kull and Narrows, according to the United States Coast and Geodetic Survey Report for 1886, is as follows:

Table Showing Tidal Discharges in the Vicinity of New York, according to United States Coast and Geodetic Survey.

*Tidal Discharge per 24 Hours, June 25, 1886.*

| | Million cu. ft. per 24 hours |
|---|---|
| East River: | |
| Ebb (westerly) | 8 909 |
| Flood (easterly) | 8 014 |
| Excess of ebb | 895 |
| Hudson River (at Thirty-ninth Street): | |
| Ebb (south) | 13 993 |
| Flood (north) | 12 451 |
| Excess of ebb | 1 542 |
| Kill von Kull (West New Brighton): | |
| Ebb (toward harbor) | 3 580 |
| Flood | 3 424 |
| Excess of ebb | 156 |
| Narrows: | |
| Ebb (seaward) | 27 639 |
| Flood | 25 407 |
| Excess of ebb | 2 232 |
| Tidal prism of bay, etc., million cu. ft. | 5 000 |

The question of the diffusion of the water of the bay has such an important bearing on the question of the disposal of the sewage which enters it that I have thought it worth while to collect some data to show the proportions of sea water and fresh water in the bay under different circumstances.

## Proportions of Salt and Fresh Water in New York Bay.

The commingling of the salt and fresh water is best indicated by the records of analyses of samples of the water taken at various points in and about the harbor. For the purpose of this study the water of the ocean beyond the range of fresh water influence is assumed to have an average of about 18 000 parts of chlorine per million, although it varies considerably in different parts of the sea and is probably not always the same in the

vicinity of New York. We may take the chlorine of Long Island Sound to be about 14 000, and of the Hudson at Poughkeepsie at about 1.5 parts per million.

From these studies it is evident that the water of New York Bay is not composed of fresh and sea water in any fixed proportion. It changes with the weather and with the season. In the lower bay it has been found to range from about 20 per cent. to 100 per cent. sea water, according to the location of the point with reference to local sources of dilution and the amount of fresh water coming down the various large rivers. A fair average for the lower bay, under ordinary conditions of weather and beyond the range of local dilution, is difficult to decide on. It is not, improbably, about 75 per cent.

The water of the Narrows has been found to vary from 43 per cent. to 77 per cent. sea water, the majority of samples averaging about 65 per cent. At the Battery the samples have ranged from 15 per cent. to 69 per cent. sea water, with an average, under what appear to be normal conditions, of about 45 per cent.

The lower Hudson is the scene of the widest variation in the proportions of sea and fresh water. In the foregoing tables it is seen that the Hudson at Spuyten Duyvil has ranged from an hourly average of 0.5 per cent. to 44 per cent. sea water for a whole day. There may be as much sea water sometimes at Croton Point as there is at other times at the Battery, 33 miles nearer the ocean. In fact, the upper limit of brackish water may be anywhere between Yonkers and Poughkeepsie. All of the figures given relate to surface conditions of water.

The cause of these differences is to be found in the rainfall, for this furnishes the fresh water which tempers the sea water. In the spring, when the discharge of the Hudson River is at its height, large quantities of fresh water force the sea water out farther and farther toward the ocean. In the late summer, when the rainfall is slight, and in winter when the tributary streams are frozen, the sea water creeps up the Hudson to a great distance. Between Yonkers and West Point the sea water is ever advancing and retreating. Every tide and wind affects it and every storm has an appreciable effect on it.

### The Phenomenon of the Underrun.

So far, we have considered only the quality of the water near the surface. There is reason to believe that the condition of the water at the bottom is somewhat different from that at

the top. Owing to its greater mineral content, the water of the sea is about 2½ per cent. heavier than fresh water. This difference tends to keep the fresh water and salt water apart. The sea water seeks the bottom and the river water the top of the bay and river.

The character of the water far below the surface is of interest in this investigation for the reason that sea water tends to precipitate sewage, causing a part of its solid ingredients to settle toward the bottom. Here the water is not so capable of disposing of the sewage as inoffensively as at the surface, because it cannot so readily renew its supply of oxygen.

It will be seen from these studies that the inflow and outflow of the water of New York Bay is not regular, but subject to a range of conditions which make flushing action uncertain and irregular. At times of abundant rain the lower Hudson appears to be well flushed out, but during dry periods sea water, and possibly sewage, flow far inland.

Observations begun in 1858 show that there is sometimes a layer of distinctly salt water beneath the brackish water in the Hudson for many miles above New York. Some persons believe that there are pockets and potholes in the bottom of the channel in which salt water and sewage accumulate. Here the sewage is thought to remain until a heavy rainfall causes a sufficient rush of water down the Hudson to clear them out. This bottom current is called the "underrun."

The underrun of salt water may be, and usually is, quite independent of surface currents. In fact, it is often directly opposed to them. In such a deep river as the Hudson, it is not difficult to imagine opposite currents one above the other, flowing at the same time. At a gaging station established by the United States Government in 1858 between Bedloe's (now Liberty) Island and Governor's Island in the upper bay, the velocity of the underrun moving up the river was found to exceed the velocity of the surface current moving toward the sea. The daily progress of the underrun was 21 miles, at a depth of 68 ft.

It would appear from this and from the fact that the surface water becomes more and more salt at points up the Hudson during dry weather, that the net result of the backward and forward movement of the tides may sometimes be to carry sewage up the river, and not out to sea, as is commonly supposed.

The following extract from the report of Prof. Henry Mitchell, contained in Appendix 15 of the Report of the United

States Coast and Geodetic Survey for 1887, page 308, gives the opinion of a well-known government observer on the sanitary significance of the underrun.

"It would seem that the drainage of New York City must be storing up in August and September at the bottom of the Hudson. Some simple tests for sulphides which we employed when the underrun was first discovered indicated that the mixture of sea and river water was recent. No 'spoiled' water in the potholes of the great central channel was found. Happily for the communities along the lower Hudson, the floods and freshets occur often enough to purge the great trench above New York City of sea water and sewer water in spite of the long inland journeys which these are prone to take in late summer and autumn, and perhaps winter."

Capacity of the Water of the Harbor to Digest Sewage.

If the conclusions of the New York Bay Pollution Commission are correct, the sewage which enters the bay is not disposed of by being carried to sea in a simple mechanical manner, but is more probably assimilated or digested by the water of the bay itself. This assimilating process is one of liquefaction and oxidation in which bacteria play an important part.

Experience and experiments have shown that the digestive capacity of a water for sewage depends largely upon the supply of oxygen which the water contains. If a sufficient supply is not available, the sewage putrefies, giving off offensive odors.

Compared with fresh water streams or the ocean, the conditions in New York Bay are not favorable for the disposal of sewage by assimilation. The constantly changing proportions of sea water are opposed to the existence of a permanent fauna and flora, and the phenomenon of the underrun shows that there is an absence of the vertical currents which are necessary for a continued supply of oxygen to the lower depths where the precipitating properties of the salt water probably carry some of the sewage.

The amount of sewage which can safely be discharged into fresh water is not a measure of the amount which sea water can dispose of satisfactorily. The digestive capacity of salt water is much less than that of fresh. Experiments carried on by Harry W. Clark for the Committee on the Charles River Dam, show that sea water normally holds less oxygen than fresh water, and that putrefaction, with the production of the exceedingly offensive gas, sulphureted hydrogen, is likely to occur when

sewage is mixed with sea water which has not a sufficient supply of oxygen to enable the aërobic bacteria to carry on their work.

The sewage which now flows into the bay enters it in a favorable manner, that is, in comparatively small amounts and at a great number of points. This aids in its general diffusion, without which no effective purification could take place.

It is impossible to say how much sewage could be discharged into New York Bay without overloading it, that is, causing its supply of oxygen to become exhausted. Should such exhaustion occur, offensive putrefaction would result, with the production of foul odors. Already there are certain localities where the water is decidedly offensive to the sight and smell. Where, however, the tidal currents are sufficient to promptly carry the impurities to the main channels and there disperse them, there is, as yet, no trouble.

The amount of organic matter discharged into the rivers and bay in the vicinity of New York is not known with exactness, but it can be approximately determined from estimates of the amounts of sewage discharged and the rainfall. The quantity of sewage discharged into the tidal waters in the neighborhood of New York has been found to be now, in 1906, about 455 000 000 gal. per 24 hr., and the amount of drainage due to rainfall, estimated on the basis of 42 in. of rain per year and a runoff of 75 per cent. over an area of about 162 miles, is about 243 000 000 gal. These together make a total of 698 000 000 gal. of drainage wastes which the rivers and harbor receive daily.

There are no data to show the composition of this drainage. If its composition is similar to that of Worcester, Mass., the only American city whose mixed house and street sewage has been analyzed, there are 1½ tons of solid, dry sludge for every million gallons, or 1 047 tons in all. Of this, about one half is probably organic matter and capable of putrefaction.

Considered as a whole, there are no indications that the bay is now being taxed beyond its capacity nor that it cannot digest considerably larger quantities of sewage, provided they are added properly, that is, through a sufficient number of outlets sufficiently far apart. What would happen if a very large amount of sewage were to be discharged at a single point is not ascertainable. There is reason to believe that it would not be disposed of without the production of offensive odors and other conditions which would be intolerable. The chief danger lies in the possibility that the sewage would not mix promptly with the water with which it should be diluted, in which event it

might be carried to inhabited shores, creep up the Hudson with tidal currents or the underrun, or rise to the surface and there form an unpleasant, discolored area, as may often be seen in neglected tidal harbors.

In considering the capacity of the bay to digest sewage, careful account should be taken of the increase of pollution to which it is likely to be subject as a result of future increase of population of New York City and the municipalities on these shores. Taking the estimates of Mr. John R. Freeman, who has given close attention to the subject of the future population of New York and its vicinity in connection with his studies of the future water supply of New York, and correcting them by more recent census returns, it appears that the population of this area will be about double that of the present population in the year 1930. If the amount of sewage increases in proportion to the population, and the rainfall remains constant, the total increase in the amount of drainage entering the waters about New York will be nearly doubled by 1930.

## Industries Affected by Pollution.

The industries of New York Bay which would be endangered by an excessive pollution of these tidal waters may be classified as follows:

(*a*) Shad fisheries; (*b*) shellfish industries; (*c*) passenger and transportation business; (*d*) excursion and bathing beach enterprises.

These will now be considered separately:

### *Shad Fisheries.*

The shad fishing industry depends upon the annual migration of the shad, *Clupia sapidissima*, from the sea up the Hudson River to spawn. The most important localities for shad fishing are in Westchester, Dutchess and Columbia counties, beside which the catch in the immediate vicinity of New York, by citizens of that state, is insignificant.

It is said that shad have been caught near the entrance to the Kill von Kull which have, when eaten, been strongly suggestive of kerosene, and that the discharge of petroleum refuse was the cause of their unpleasant taste.

The following statistics of the shad industry in the vicinity of New York Bay are taken from a report of the United States Commission of Fish and Fisheries for 1902, page 449.

TABLE 7. YIELD OF SHAD IN THE VICINITY OF NEW YORK BAY CREDITED TO CITIZENS OF NEW YORK STATE IN 1901.

| County. | Pounds of Fish. | Value. |
|---|---|---|
| New York | 3 600 | $250 |
| Kings | 45 975 | 2 715 |
| Richmond | 118 700 | 6 360 |
| Total | 168 275 | $9 325 |

The yield credited to citizens of New Jersey was valued at $61 508.

When it is considered that the shad industry of New York State yielded in 1901, 3 432 472 lb. of fish, valued at $110 682, and was greater in that year than in any year since 1888, it does not seem likely that the growing pollution of the New York Bay has as yet done material injury to the industry as a whole. It is true, however, that the catches of more recent years have been much smaller than that of 1901.

*Shellfish Industries.*

The upper part of New York Bay once contained extensive oyster beds. They extended from Staten Island to above Newburgh. Bedloe's Island, now called Liberty Island, was known as Oyster Island, and two reefs which lie to the south of it were called the Little Oyster Islands. Oysters grew there naturally and abundantly without planting. In fact, the oysters were so plentiful that the public was allowed to gather them with little or no restriction, with the result which has so often followed this open-handed policy. To-day these extensive grounds have become exhausted. I have not found that the pollution of the bay has affected the growth. At the present time the cultivation of oysters in the bay is carried on almost exclusively below the Narrows. The Jersey Flats still furnish a small amount of natural seed and a few grossly polluted market oysters are taken there. Attempts to raise seed in the vicinity of Piermont, just above the Palisades, recently, resulted in failure.

The value of the oyster beds in New York Bay below the Narrows is very large. The principal grounds are owned by the state, on the southeast shore of Staten Island, and are let out at a nominal rental to those who apply for the privilege of cultivating them. Nearly the whole shore, from a point near the mouth of the Raritan River to the neighborhood of Hoffman

Island, is now under cultivation. The total area of the beds is estimated at about 30 sq. miles. Prominent oystermen have estimated the yield from these grounds at 500 000 bu. per annum, the Bureau of Shell Fisheries of the Forest, Fish and Game Commission of New York State has estimated it at more than four times this and the United States Commission of Fish and Fisheries has estimated it at about 300 000 bu. for 1901. The value of the oysters is commonly estimated at $1 per bu., although they sometimes bring a much higher price.

Table 8. Extent of the Oyster and Clam Fisheries of Richmond County, N. Y., in 1901, as given by the United States Commission of Fish and Fisheries.

| Items. | Number. | Value. |
|---|---|---|
| Persons: | | |
| On vessels fishing | 170 | |
| On vessels transporting | 120 | |
| In shore or boat fisheries | 259 | |
| Shoremen | 16 | |
| Total | 565 | |
| Vessels fishing | 36 | $88 900 |
| Tonnage | 477 | |
| Outfit | | 29 387 |
| Vessels transporting | 50 | 48 850 |
| Tonnage | 619 | |
| Outfit | | 11 847 |
| Boats | 349 | 42 645 |
| Apparatus — vessel fisheries: | | |
| Dredges | 128 | 6 205 |
| Tongs | 40 | 323 |
| Rakes | 18 | 144 |
| Apparatus — shore fisheries: | | |
| Dredges | 6 | 150 |
| Tongs | 318 | 2 569 |
| Rakes | 375 | 3 159 |
| Shares and accessory property | | 17 885 |
| Total investment | | $252 064 |
| **Product Taken.** | **Bushels.** | **Value.** |
| Clams, hard, public reefs | 21 900 | $18 485 |
| Oysters, market, private areas | 291 841 | 273 617 |
| Oysters, seed, public reefs | 8 100 | 3 430 |
| Oysters, seed, private areas | 6 000 | 3 000 |
| Total products | 327 841 | $298 532 |

Some hard clams, or quahogs, are taken in the same locality. The only available estimate of the quantity of the clams is that

given by the United States Commission of Fish and Fisheries, which places the annual output at 21 900 bu.

Table 8 gives details of the oyster and clam business in this region as supplied by government authorities.

The shellfish industries in this vicinity credited to citizens of New Jersey are considerable. The value of the products, as given by the United States Commission of Fish and Fisheries, for 1901 was $680 854. The foregoing table does not represent the whole produce of shellfish from New York Bay. There are small oyster grounds and clam beds in Gravesend Bay, within the limits of New York City. Other localities where shellfish are taken in the vicinity of New York Bay, are Newark Bay, Raritan River, the bend of the Horseshoe, and the mouth of the Shrewsbury River. There are extensive natural seed beds in the Arthur Kill.

The analyses of the New York Bay Pollution Commission show that most of the oysters grown in the lower bay are not polluted, but that those which are taken from contaminated water are practically certain to be contaminated themselves.

The oysters taken from the Staten Island beds are not always shipped direct to market, but are first taken to some convenient stream of fresh or brackish water and there allowed to remain from high to low tide. In this way the size of the oysters is greatly increased. Not infrequently the oyster absorbs bacterial poisons from the water. Some of these "drinking" places, as they are called, in the vicinity of New York Bay are among the most dangerous to be found anywhere. One stream, known as Lemon Creek, on the southeast side of Staten Island, drains a populated area of 2 010 acres and has numerous privies and other sources of pollution on its banks. Topographical inspections and analyses of samples of water and oysters taken from the mouth of this stream have shown that the oysters are grossly polluted. Another and, if possible, more dangerous "drinking" ground is situated at Tompkinsville, Staten Island. This stream flows from a thickly populated area of 2 960 acres. The sewage which is discharged into the Kill von Kull on both sides of this place, within a distance of three miles, exceeds 7 000 000 gal. per 24 hr. During the oyster season 10 000 bu. of oysters are often treated here per day. Sloops come, not only from the neighborhood of New York, but often from very distant points, to "drink" their oysters at Tompkinsville before offering them for sale at the city markets. The "drinking" should be forbidden by law.

*Passenger Transportation Business.*

The business of transporting passengers across the bay is already large and is constantly increasing. The majority of the passengers are commuters who do business in one part of the city and live in another, or in the country, and go back and forth every day on the boats of the ferry companies.

The pollution of the bay, if unrestrained, might affect the business of these companies in two ways: The number of passengers would decrease if public health were endangered by the trip, or if the water became markedly offensive to the sight and smell.

A more detailed idea of the extent of the transportation business in the waters about New York may be understood from the following table which has been compiled from data courteously supplied by the United States Steamboat Inspection Service.

Table 9. Number of Passengers Carried by the Principal Ferries in the Vicinity of New York in 1903.

| Name of Ferry Company. | Number of Passengers. | Route Across. |
|---|---|---|
| Brooklyn Ferry Company.. | 39 911 317 | East River. |
| Hoboken Ferry Company.. | 32 000 000 | Hudson River. |
| Union Ferry Company..... | 30 687 096 | East River. |
| Penn. R. R. Company..... | 30 337 493 | Hudson River. |
| Erie R. R. Ferries......... | 16 667 252 | Hudson River. |
| L. I. R. R. Ferries......... | 15 639 250 | East River. |
| C. R. R. of New Jersey Ferries................ | 10 700 862 | Hudson River — New York Bay. |
| S. I. R. T. Ferry........... | 7 929 000 | New York Bay. |
| W. S. R. R. Ferries........ | 5 873 886 | Hudson River. |
| N. Y. and E. R. Company.. | 4 309 700 | East River.- |
| Nassau Ferry Company.... | 2 680 000 | East River. |
| N. Y. & S. Brooklyn Ferry Company.............. | 1 720 000 | East River and New York Bay. |
| Fort Lee Ferry............ | 1 705 659 | Hudson River. |
| Total................ | 194 161 515 | |

Of the total number of passengers shown in Table 9, about 8 811 000 traveled directly across the center of upper New York Bay.

*Excursions and Bathing Beaches.*

For about six months of the year excursion steamers ply about the bay and carry large numbers of passengers in search of pleasure and health. Most of these steamers have fixed desti-

nations, such as picnic grounds and bathing beaches, but some merely sail about without landing their passengers. The total number of passengers carried by excursion steamers in the New York district in 1905 was about 2 300 000. It is obvious that a condition of the water which would be capable of injuring the business of transporting commuting passengers would be certain to do at least equal injury to the excursion business.

A large proportion of the people who patronize the excursion steamers do so in order that they may reach in a pleasant and expeditious manner what are called "day pleasure resorts." These are often, in reality, extensive bathing beaches with hotels, restaurants and a great variety of amusements. The largest day pleasure resort near New York is Coney Island; others are Midland Beach and South Beach, on the Staten Island shore. These are all located in the lower bay, somewhat beyond the Narrows. Millions of dollars have been invested at these resorts to attract visitors, and the places are deservedly popular. They would suffer material loss in patronage if the water became sufficiently polluted to be offensive.

Bathing is far more common in the upper bay than is generally supposed. In the year 1903 over 3 000 000 baths were taken in the floating bath houses maintained by the city of New York on the water front. The number of baths taken in the last two years has not been ascertainable.

## Conclusions.

The studies which have been outlined in the foregoing pages lead the New York Bay Pollution Committee to certain definite conclusions which may be briefly summarized as follows:

(1) The effects of the present pollution of New York Bay, although not great, are nevertheless measurable.

(2) A careful study of the proportions of sea water and fresh water in the bay and rivers about New York shows that the sewage of New York City is not promptly flushed out to sea, except during freshets in the Hudson.

(3) The water of the incoming tide is not ordinarily much purer than the water of the outgoing tide in the upper bay and Hudson River.

(4) It is probable that most of the sewage which enters the bay is disposed of in the bay by animals and plants, chiefly the bacteria which live in the water.

(5) The most useful effect of the tide is its production of currents whereby the sewage becomes mixed and diffused.

(6) The drainage which now enters the bay does so in a favorable manner for diffusion; that is, from a large number of outlets situated along an extensive shore line.

(7) How much sewage and other organic matter can be emptied into the bay without killing those forms of life which now destroy it, and so creating a general nuisance, it is impossible to say. This is a matter of great importance, but its proper study requires analyses and experiments which were beyond the reach of the New York Bay Pollution Commission.

(8) Compared with fresh water streams or the ocean, New York Bay is not a favorable place for the inoffensive disposal of sewage.

(9) · Should the bay become overloaded with sewage the odors which will arise from it will be particularly offensive.

(10) The total amount of solid matter which now enters the bay with house and street sewage every 24 hr. is approximately equivalent to 1 047 tons of dry sludge. About one half of this is organic matter.

(11) Long before a general nuisance is produced, local nuisances will occur, as may be seen at present where sewers and drainage from industrial works empty into still, or comparatively still, water.

(12) Observations made by the United States Government show that a distinct current of salt water sometimes runs up the Hudson under the fresher water, without respect to surface currents, and it has been suggested that this underrun carries sewage from New York City up the river and empties it into potholes or depressions in the bed of the channel, where it remains until washed out by freshets.

(13) The oyster beds in New York Bay are almost exclusively located on the southeast side of Staten Island and Gravesend Bay.

(14) Most of the oyster and clam beds are now free from dangerous pollution, although there are some on the Staten Island shore near the Narrows and the Kill von Kull, and a few in Gravesend Bay, which are nearer sewer outfalls than is proper.

(15) Analyses of oysters and clams show that shellfish which are grown or immersed for some hours in polluted water become polluted themselves.

(16) The increasing amount of pollution to which the waters of New York Bay are subject makes it seem only a question of time when oyster culture will be driven from this locality; but

with wise and careful protection, a large part of the present oyster grounds can be kept safe for years to come.

(17) The almost universal custom in this vicinity of "drinking," that is, bleaching and bloating, oysters in polluted streams of fresh water, places all shellfish in this market under suspicion of being contaminated.

(18) The pollution of the bay has had no visible effect upon the number of fish caught in the vicinity of New York, although petroleum and other industrial wastes have occasionally affected the flavor, and consequently the value, of shad.

(19) The transportation of passengers on ferry boats is one of the most important industries connected with the bay, the number of passengers transported in the New York district in 1903 having been 204 000 000, and the number which traveled directly across the center of the upper bay 8 811 000. This business would be seriously injured if the water became offensive to sight and smell.

(20) Unrestricted pollution of the bay would destroy the healthfulness and attractiveness of the parks and recreation piers which have been built by the city of New York on the water fronts for the benefit of the poor.

(21) Excursion steamers carried about 2 300 000 passengers to bathing beaches and other day summer resorts on or near the bay in 1903. The most important of these places are located a little beyond the Narrows in the lower bay and represent a total investment of several million dollars. The pollution of the bay, unless restricted, will eventually injure the healthfulness and business value of these resorts.

(22) The natural increase in population of New York and vicinity will, by 1930, increase the present amount of pollution about 65 per cent.

## DISCUSSION.

Mr. Allen Hazen. — One of our New York dailies, speaking of Dr. Soper's admirable work in connection with the ventilation of the subway, referred to him as the best all-round germ detective in New York. I think he has fully justified that reputation to-night. Since he has investigated the oyster question I have had to forego the pleasure of eating them raw, almost entirely, and I am fond of oysters. It is only once in a great while, when he has been good enough to send up a bushel from his own private plantings, that I have been able to indulge that taste.

Mr. Weston has been talking to me about garbage disposal, and it was suggested that if we were more careful in our market-

ing, and if we had French cooks to save the scraps and to serve them to us in attractive form the day after, the quantity of garbage to be taken care of would be greatly reduced.

I do not know but we could go a little further. Supposing we were to regulate our food according to the dietaries of Mrs. Richards and limit ourselves to the number of calories that we really need, wouldn't the sewage disposal problem be largely solved? For I think that the troublesome matters are due largely to what we eat in excess of our actual needs. And that raises the question, What are the eating habits of the next generation going to be? Is it fair to make *per capita* computations based on the data of the present time and apply them to the twenty-first century without taking into account the dietaries of the people at that time, which we cannot hope to know?

Some weeks ago I took up these figures which Dr. Soper has used to-night, as they are given in the printed report of the New York Bay Pollution Commission, and went over them in a preliminary way, and made some pencil figures on the margins of the leaves of the pamphlet. The line of reasoning that I followed seems to offer some promise, and I should like to know what Dr. Soper thinks of it, and whether he has followed it to its conclusions.

The quantity of water that comes into New York Harbor through the Narrows and goes out again, if it is reduced to cubic feet per second, is a tremendous quantity. Altogether it represents a flow of over 3 cu. ft. per second per thousand of population, for 100 000 000 people. That is a pretty large population, more than the present population of the whole United States, but there can be no doubt that diluting the sewage from it with this amount of clean, cool sea water and with the strong tidal currents which exist would render it reasonably inoffensive.

But, of course, it is not true that all the water that comes in with every tide is new water. On the other hand, it is equally untrue to assume that the water that comes down the Hudson River and other tributaries of the bay, and which is represented by the line on Dr. Soper's chart for comparison with the sewage, is the only water available for diluting the sewage. If that were true, if the so-called piston method of computation were correct, if the water that comes back on the flood were the same water that went down on the ebb, then the water of New York Harbor would be fresh; there would not be a particle of salt water in it. The fact that there is salt water in the harbor, and lots of it,

is conclusive evidence that sea water comes in with every tide; and the fact that the water in New York Harbor is very salt is evidence that the volume of sea water coming in with each tide is enormous.

I took the figures from the report of Dr. Soper's commission. There are figures for the estimated volume of fresh waters coming in; for the volumes of tidal flow up and down; and for the percentage of sea water in the water at the different points, as computed from the chlorine of the water at the surface. From these it is easy to get an equation from which can be computed the proportion of the outgoing water that comes back again, and the proportion of new sea water which enters the harbor at each tide which has never been in the harbor before. And taking the figures from this same report and making the computation in this way, I found that about 79 per cent. of the water that once goes through the Narrows comes back again. The other 21 per cent. does not come back, but instead, 23 per cent. of the flood tide is made up of new sea water, water that has never been in the harbor before. And following the same computation at a point on the North River for which figures were given, the percentage was only one or two less, — almost the same thing.

Now these analyses relate to the water at the surface. Dr. Soper has told us about the underrun. It seems very clear to me that if that were taken adequately into account, the percentage of sea water that enters with every flood tide would be much larger than 23 per cent. But there are no data to figure that on. I think such data ought to be secured. I think perhaps the way to secure them would be to have a floating laboratory, such as is used in London, and which has been so largely instrumental in establishing the harbor conditions there. But such data do not exist at the present time. It is simply guessing to go beyond the figures in the report, and even those figures must be regarded as inadequate for such a computation. But if 23 per cent. of the water that comes in with every flood tide is new, fresh sea water, then that water would be sufficient to dilute to the extent I have mentioned the sewage from a population of 23 000 000 of people, — five times, in round numbers, the population now discharging sewage into the harbor, and Dr. Soper's analyses certainly bear out that proposition, for they indicate a water polluted to only a small fraction of the extent which would be necessary to make it offensive.

Of course, it is also true that when New York reaches such a population as 25 000 000, a great deal of it will be on Staten

Island and on Long Island, and so located that it will not discharge its sewage into the ocean through the upper harbor, and these computations do not take into account the conditions of the lower harbor, which are, no doubt, vastly more favorable for the dispersion of sewage. And so it looks as if it might be centuries rather than decades to the time when radical measures for purifying the sewage of New York City will be required.

There is another side. The degree of dilution of sewage in a body of water to render it satisfactory depends to a very large extent upon the uses to which the body of water is to be put. I have taken the ground strongly in some cases that the character of the body of water receiving sewage had to be taken into account. A standard suitable for one place is not suitable in another. In the case of a stream flowing through country where there are only a few scattered dwellings, the standard must be very different from that where the stream flows through a densely built-up territory and where a nuisance would be objectionable to thousands of people. And in New York Harbor millions would be affected.

I suppose there is no body of water in the world a bad condition of which would affect more directly and closely the comfort and happiness and even the health of a larger number of people; and it may be, when we come to that, that the degree of pollution allowable will be quite different from that which has been established by experience in other cases.

But at any rate, it looks as if any radical change in the method of disposal of New York sewage was a good long way in the future, and as if the habits of the people of future generations, and a lot of other things that we don't know much about, might be elements in the conditions that will finally control. And so I believe that what is wanted at this time is more investigation. I mean adequate and continued investigation of the condition of the water at different depths and at different places, and a study of the currents and of the conditions of sewage dilution. And that is what the situation calls for at the present time, rather than for any radical changes in the places at which sewage is discharged.

[NOTE: The computations upon which the above statements are based are as follows:

Let $E$ = the volume of the ebb tide passing a given place;

Let $R$ = the volume of river water in the ebb tide passing;

Let $S$ = the average proportion of sea water in the ebb tide.

The total quantity of fresh water that goes out at one ebb will then be E(1–S).

Of this, R, the volume of river water, goes down not to come back. The rest of the fresh water going down, namely, E(1–S) – R, comes back with the flood tide.

The proportion of the total amount of fresh water which goes down not to come back is then

$$\frac{R}{E(1-S)}$$

It may be assumed that the proportion of sea water going down not to come back will be the same as the proportion of fresh water going down not to come back; for when once mixed it cannot be supposed that fresh and salt water will ever separate, and the proportion computed for fresh water may, therefore, be applied to the total volume of water going out with each tide.

Applying this to the Narrows, we have

E = 320 000 cu. ft. per sec. (computed from data on p. 35);
R = 23 883 cu. ft. per sec. (p. 38);
S = 65 per cent. (p. 67).

Percentage of the volume of each ebb which does not come back at the Narrows,

$$\frac{R}{E(1-S)} = 21 \text{ per cent.}$$

And for the Battery

E = 161 000 cu. ft. per sec. (computed from data on p. 35);
R = say, 18 000 cu. ft. per sec.;
S = 45 per cent. (p. 67).

Percentage of the volume of each ebb tide which does not come back,

$$\frac{R}{E(1-S)} = 20 \text{ per cent.}$$

Of the gross amount of water flowing out of the Narrows with each ebb:

7 per cent. is river water on its last trip out;
28 per cent. is river water that will come back;
14 per cent. is sea water on its last trip out;
51 per cent. is sea water that will come back.

Allowing for the smaller volume of the flood tide as compared with the ebb, 23 per cent. of the whole volume of the flood tide must be new sea water which has never been above the Narrows before, equal to a flow of about 68 000 cu. ft. per sec. throughout the 24 hr.

It is well known that the average per cent. of sea water in the whole stream, taken from top to bottom, is far larger than in the surface water, which alone is represented in the data above indicated. If this difference could be taken into account, it is certain that the computed volume of new sea water entering the harbor with each tide would be much larger, — perhaps twice as large as the figure above computed.

There is another element of uncertainty in this computation. The amount of river water entering the harbor must vary enormously from month to month, and even from day to day. The figure given is understood to be a probable average figure. The actual flows when the samples from which the percentage of sea water was computed may have differed considerably from

Table Showing Extent of Shellfish Industry in Boston Harbor, 1905.

| Location. | Estimated Quantity per Day When Taken. | Market. |
|---|---|---|
| Winthrop and Snake Island, | 35 bushels*. . . . . . . . . . . . | Boston–Winthrop Private. |
| Chelsea Point to East Boston | Very few . . . . . . . . . . . . | Private. |
| Chelsea River. . . . . . . . . . . . . . | 5 bushels. . . . . . . . . . . . . . | Boston. |
| Mystic River. . . . . . . . . . . . . . | 15 bushels. . . . . . . . . . . . . | Boston. |
| Old Harbor. . . . . . . . . . . . . . | 3 bushels. . . . . . . . . . . . . . | South Boston. |
| Dorchester Bay. . . . . . . . . . . . | 50 bushels†. . . . . . . . . . . . | Boston. |
| Moon Island. . . . . . . . . . . . . . | 8 bushels‡. . . . . . . . . . . . . | Nantasket. |
| Quincy Bay. . . . . . . . . . . . . . | 5 bushels at Half Moon Island. . . . . . . . . . . . . . | Nantasket. |
| | 5 bushels elsewhere. . . . | Private. |
| Weymouth Fore Fiver. . . . . . | 5 bushels‡. . . . . . . . . . . . . | Private or local. |
| Weymouth Back River. . . . . | 3 bushels. . . . . . . . . . . . . . | Private. |
| Hingham Harbor. . . . . . . . . . | 8 bushels. . . . . . . . . . . . . . | Private. |
| Weir River. . . . . . . . . . . . . . . | 11 bushels. . . . . . . . . . . . . | Nantasket. Private. |
| White Head to Allerton. . . . . | 5 bushels. . . . . . . . . . . . . . | Nantasket. |
| Apple Island. . . . . . . . . . . . . . | Few. . . . . . . . . . . . . . . . . . . | Private. |
| Bird Island Flats. . . . . . . . . . | No clams; oysters planted yearly. | |
| Governor's Island. . . . . . . . . . | Few. . . . . . . . . . . . . . . . . . . | Private. |
| Thompson's Island. . . . . . . . | 5 bushels§ . . . . . . . . . . . . | Boston. |
| Spectacle Island. . . . . . . . . . . | 5 bushels. . . . . . . . . . . . . . | Nantasket. |
| Long Island. . . . . . . . . . . . . . . | Few. . . . . . . . . . . . . . . . . . . | Private. |
| Rainsford Island. . . . . . . . . . . | None. | |
| Peddocks Island . . . . . . . . . . . | North side, none; south side, 4 bushels. | |

* Dug mostly near Snake Island.

† Dug mostly along east side of river; very few dug from Squantum to Chapel Rock.

‡ Dug either side of roadway.

§ The larger quantity is dug on northwest shore.

the average, and, if so, this would make a difference in the result obtained. Data could be secured which would take this at least approximately into account, and a more accurate computation made, based upon such data.]

Mr. X. H. Goodnough.—*Results of the Examinations of Shellfish from Flats in Boston Harbor.* The range of tide in Boston Harbor is about 10 ft., and at low tide large areas of flats are exposed in nearly all parts of the harbor, many of which contain clams in considerable numbers. No definite information is available showing the number of clams collected for use as food from the clam flats in Boston Harbor, but in the course of the investigation estimates of the probable number taken from each of the different flats have been obtained from various sources, and the general average of these estimates is the best indication available as to the extent of the shellfish industry in Boston harbor.

Previously to 1905 a considerable number of samples of clams had been collected from the flats at several places in Boston Harbor and analyzed, the results showing, especially in the case of those collected from the flats in the Charles River, the presence of bacteria characteristic of sewage.

In 1905 the work of obtaining samples of clams from various localities in each of the flats was begun early in the season and completed in the latter part of October.

In the collection of the samples usually three clams were taken at each place and combined at the laboratory and analyzed as a single sample. The analysis consisted in determining whether *B. coli* were present either in the water in the shell of the clam or in the body of the clam itself. In many cases, owing to the presence of the organism known as sewage *Streptococcus*, the determination of the number of coli present was impracticable, and the presence of the sewage *Streptococcus* has been noted.

In all cases, samples of sea water have been collected at points adjacent to the places on the flats from which the samples of clams have been taken, and bacterial analyses of these samples of water have been made showing both the total number of bacteria present and the number of *B. coli* in the sample.

The following table contains a summary of the results of the examinations of samples of clams and sea water from the various localities, from which it appears that more than three quarters of the samples of clams collected in various parts of the harbor contained either the colon bacillus or sewage *Strepto-*

*coccus* and about 86 per cent. of the samples of sea water collected from waters adjacent to the flats contained the colon bacillus.

The results of the examination of samples of clams from 125 localities covering all portions of the harbor in which these shellfish could be found showed the presence of the colon bacillus or sewage *Streptococcus* either in the shell water or in the body of the clam in 96 of the samples, or about 77 per cent. of those examined. Out of the 144 samples of sea water collected at points opposite the clam flats, 124, or about 86 per cent., contained either the colon bacillus or sewage *Streptococcus*.

Summary of Results of the Examinations of Samples of Clams and Sea Water from Boston Harbor, 1905.

| Location. | Number of Samples of Clams Examined. | Number Containing Coli in Body of Clam. | Number containing Sewage Streptococcus in Body of Clam. | Number Containing Coli in Shell Water. | Number Containing Sewage Streptococcus in Shell Water. | Number Containing Neither Coli nor Sewage Streptococcus in Body of Clam or in Shell Water. | Number of Samples of Sea Water Examined. | Number Containing Coli or Sewage Streptococcus. | Number Free from Coli or Sewage Streptococcus. |
|---|---|---|---|---|---|---|---|---|---|
| Old Harbor | 5 | 2 | 1 | 5 | 0 | 0 | 7 | 7 | 0 |
| Between Calf Pasture Pt. and Savin Hill | 5 | 2 | 0 | 5 | 0 | 0 | 5 | 5 | 0 |
| Savin Hill to Commercial Point | 2 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 2 |
| North side of Neponset River estuary | 8 | 2 | 0 | 3 | 0 | 5 | 7 | 2 | 5 |
| South side of Neponset River estuary | 6 | 0 | 0 | 1 | 0 | 5 | 6 | 6 | 0 |
| North side of Squantum | 2 | 0 | 2 | 0 | 2 | 0 | 6 | 6 | 0 |
| North side Moon Island causeway | 2 | 0 | 2 | 1 | 0 | 0 | 3 | 3 | 0 |
| South side Moon Island causeway | 3 | 1 | 1 | 0 | 1 | 1 | 3 | 3 | 0 |
| Squantum to Black's Creek | 6 | 0 | 3 | 2 | 0 | 1 | 4 | 4 | 0 |
| Black's Creek to Nut Island | 3 | 3 | 0 | 1 | 0 | 0 | 2 | 2 | 0 |
| Weymouth, Fore River | 15 | 9 | 1 | 3 | 5 | 3 | 12 | 11 | 1 |
| Weymouth, Back River | 8 | 5 | 3 | 2 | 0 | 0 | 8 | 8 | 0 |
| Weymouth, Back River to Crow Point | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 0 |
| Hingham Bay | 8 | 1 | 4 | 5 | 0 | 1 | 6 | 3 | 3 |
| Nantasket Bay | 7 | 5 | 1 | 4 | 1 | 1 | 10 | 10 | 0 |
| Hull Bay | 6 | 3 | 1 | 2 | 2 | 1 | 6 | 4 | 2 |
| Mystic River above Chelsea Bridge | 8 | 5 | 2 | 4 | 0 | 1 | 6 | 6 | 0 |
| Chelsea River | 3 | 3 | 0 | 3 | 0 | 0 | 6 | 6 | 0 |
| East Boston to Chelsea Point | 7 | 4 | 2 | 6 | 0 | 1 | 10 | 6 | 4 |
| Chelsea Point to Point Shirley | 7 | 2 | 1 | 1 | 2 | 3 | 7 | 7 | 0 |
| Apple Island flats | 1 | 1 | 0 | 1 | 0 | 0 | 3 | 1 | 2 |
| Governor's Island Flats and Bird Island Flats | 3 | 1 | 0 | 1 | 0 | 2 | 5 | 4 | 1 |
| Thompson's Island | 3 | 2 | 1 | 2 | 0 | 0 | 5 | 5 | 0 |
| Spectacle Island | 2 | 0 | 2 | 1 | 0 | 0 | 3 | 3 | 0 |
| Long Island | 3 | 0 | 3 | 3 | 0 | 0 | 6 | 6 | 0 |
| Peddocks Island | 2 | 0 | 0 | 0 | 0 | 2 | 3 | 3 | 0 |
| Totals | 125 | 51 | 30 | 56 | 13 | 29 | 144 | 124 | 20 |

No scallops or quahogs grow in this harbor and oysters do not grow there naturally. It is said, however, that a few oysters are planted in a shoal in the upper part of the harbor from which they are taken for consumption in the city, as needed.

At the same time that the samples of shellfish were being collected in various parts of Boston Harbor examinations of the water of the harbor were being made to determine its condition and the effect upon the waters of the harbor of the discharge into them of the sewage of the city and Metropolitan districts at various points. The results of these investigations show, in general, that the waters in all parts of the harbor are affected in a greater or less degree by pollution from the sewers and other wastes from the large population about it.

While in general the harbor is free from the appearance of sewage pollution, except in the immediate neighborhood of the sewer outlets, there can be no question of the serious danger to health involved in the use of oysters or other shellfish which have been planted at any point within the harbor or in the neighborhood of the islands at the mouth of the harbor, if these shellfish are used for food without thorough cooking.

A complete report of the results of the examination of the waters of the harbor will be published in the report of the Massachusetts State Board of Health for the year 1905.

Mr. H. W. Clark. — I will take but a very few minutes, Mr. President, and will speak only in regard to the shellfish side of this question. Dr. Soper has remarked that here in Boston we seem to like the Blue Point oysters. I'd like to say in reply to that that the Little Neck clams Mr. Goodnough mentioned as being gathered down near the New Bedford sewers go very largely to New York. That is, they did go to New York, but probably they won't keep on sending them after to-night. Mr. Hazen has spoken of the joys of eating raw oysters and also of the fact that he does not eat them any more unless Dr. Soper sends them to him. I presume, however, that he eats any old oyster that has been cooked from whatever source it comes. During the past five years we have been making a good many studies at the experiment station in regard to both raw and cooked oysters, and raw and cooked clams. We find, of course, that a considerable percentage of clams and oysters from sewage-polluted sources contains sewage bacteria, and that the clams and oysters from non-polluted sources are free, generally, from sewage bacteria. Through five years I have been running at Lawrence, with Mr. Gage's assistance, a scientific cooking

school that I think would make Mrs. Rorer green with envy. Some of you probably have heard of Mrs. Rorer. We have cooked clams and oysters in all the common ways and have bought such delectable dishes as oyster stews and clam chowders and fried clams in restaurants and hotels for examination at the laboratory, and never yet have bought an oyster stew for examination that did not contain many bacteria. We have found, during our work, that that very favorite, succulent New England dish known as steamed clams is not, when the shell of the clam opens,— the point at which the clams are considered fit to eat, — cooked or raised to a sufficient temperature to kill the bacteria present, and in order to kill coli, you have got to steam the clams until they are really unfit to eat.

We find in regard to oyster stew that the usual manner of making an oyster stew is to heat the milk to the boiling point, throw in the oysters and then serve as soon as possible. I think one of my men said he saw an oyster stew cooked and put before him in thirty seconds in one of the hotels here in the city. If the oysters in this stew were polluted and contained sewage bacteria, they still contained them when the stew was served; in fact, in order to make oyster stew safe to eat, you have got to cook the oysters for a considerable time in the milk. This makes the oysters somewhat tougher than some people like to have them. And the same with fried clams and fried oysters. While you can cook them so that the bacteria are killed, simply cooking them until the oysters and clams are considered in just the right condition to eat does not always kill the bacteria and does not destroy the coli present. In fact, it is pretty safe to say that when you eat cooked shellfish, you are not generally eating sterile shellfish; that is, danger is still present when you are eating cooked shellfish, although, of course, to a less degree than when eating raw shellfish.

Besides this, we have made experiments upon the keeping of oysters and clams under market conditions; that is, we have taken oysters and clams and polluted them by placing them in sewage-polluted water for a certain number of hours and then put them on ice, just as you see them piled up in oyster houses, etc., and examined a certain number each day, hoping when we started that the clams or the oysters would see fit to digest or destroy any sewage bacteria present and thus purify themselves. But we have found that the sewage bacteria stayed in the intestines of the clam or the oyster, or upon them, as long as we were able

to keep the shellfish alive upon ice, and that was some fourteen days, I think; so that you are not sure that keeping shellfish under market conditions kills or destroys the pollution; in fact, it generally does not. I do not think there is anything else I care to say about the question this evening.

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[NOTE. Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by October 1, 1906, for publication in a subsequent number of the JOURNAL.]

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## CONTENTS AND INDEX.

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# CONTENTS.

VOL. XXXVII, July–December, 1906.

**For alphabetical index, see page v.**

# INDEX.

VOL. XXXVII, July-December, 1906.

ABBREVIATIONS. — D. = Discussion; I. = Illustrated.
Names of authors, etc., are printed in *italics*.

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## THE NORTHERN BOUNDARY OF MASSACHUSETTS.

By Nelson Spofford, Member of the Boston Society of Civil Engineers.

[Read before the Society December 21, 1904.]

By way of preface a brief history of the New Hampshire boundary and the controversy with Massachusetts may not be out of place, this matter having been a subject of contention ever since the first settlement of the country. Volumes would be required to contain a small part of what has been written on this subject; consequently we must omit much early history, and take up the year 1740. Upon the basis of the old charter that gave to the colony of Massachusetts Bay all the land between a line 3 miles south of the Charles River and 3 miles north of the Merrimack River, Massachusetts had persisted in the claim to 3 miles north of every part of the Merrimack River, and had chartered towns as far north as Concord, N. H. New Hampshire had disputed that claim on the ground that when that charter was granted the Merrimack River was supposed to run about due east for its entire length; and New Hampshire claimed for her southern boundary a straight line, due west from a point 3 miles north of the mouth of the Merrimack River. One John Tomlinson and his assistant managed New Hampshire's case before the King's Council; and a decree was made bearing date of August 5, 1740, in the following words:

"That the northern boundaries of the province of Massachusetts Bay are and be a similar curved line, pursuing the course of the Merrimack River, at 3 miles distance on the north side thereof, beginning at the Atlantic Ocean, and ending at a point, due north of a place, in the plan returned by the com-

missioner, called Pautucket Falls, and a straight line drawn from thence due west, across said river, till it meets his Majesty's other governments."

This line crossed the Merrimack River about 12 miles further south than the line claimed by New Hampshire, and cut from the jurisdiction of Massachusetts 16 townships and transferred them to the jurisdiction of New Hampshire. It is needless to remark that Massachusetts was astounded at this result of referring the case to the King in Council, and New Hampshire was equally elated at the victory thus obtained. No effort was spared on the part of Massachusetts to have this decree annulled or amended, but all to no purpose. New Hampshire immediately took possession of this teiritory that had been under the jurisdiction of Massachusetts for more than a hundred years, while Governor Belcher was ordered to have the line run in accordance with the decree (on pain of dismissal from his office if the work was neglected), and the work was executed on the ground, March and April, 1741. George Mitchell, of Portsmouth, N. H., was appointed by Governor Belcher to run the curved line opposite and 3 miles north of the Merrimack River, from the ocean to Pawtucket Falls. Richard Hazen, of Haverhill, Mass., was appointed to run the due west line, but Massachusetts took no part in that work, and New Hampshire paid all the bills, Belcher being governor of both provinces at that time.

The lineal descendants of Richard Hazen are still living in Hampstead, N. H., and a copy of the diary that Hazen kept on that work was obtained from one of them a few years ago and is now on file at the State Treasurer's office at Concord. It has been printed in New Hampshire state papers, but has never been printed by the Commonwealth of Massachusetts, although Richard Hazen was a Massachusetts man to all intents and purposes. The writer first saw it in the *New England Historical and Genealogical Register* for July, 1879, page 323. A few passages somewhat abridged and "edited" will serve to exhibit the character of the work.

"Friday, March 20, 1740. At eight o'clock, forenoon, we set out from my dwelling house in Haverhill with our provisions on small hand sleds which we hauled up the Merrimack River with great difficulty and danger of falling through, most of the falls in the river being broke open and in other places the ice was thin and very rotten, and at eight o'clock at night we came to Mr. Richard Hall's at Tewksbury and lodged by his fireside.

"Saturday, March 21. At break of day we went from Mr. Hall's and passed over Concord River on the ice without any apparent danger, notwithstanding it was open a little above us and below, and at nine o'clock, forenoon, we came to Colonel Varnum's where about ten o'clock George Mitchell, Esq., and company, who had been taking the bends of Merrimack River from the sea in order to run similar lines in a proper season for it, also arrived, and the colonel, having very generously dined both companies at his own expense and cost and concluded at what part of the falls to begin to measure a due north line (the place concluded on being directly opposite to Tyng's saw mill and called the Great Bunt).

"The said Mitchell set forward on his course, and measured the said 3 miles which ended about 14 poles southerly of Colburn's old meadow and near the easterly end of it, where the said Mitchell caused a pitch pine to be marked and lettered with (M) on the southerly side for the mark of the Massachusetts Bay; and (N. H.) for New Hampshire, on the opposite side, and erected a pillar of stones round the same tree, and then we parted, the said Mitchell returning home, and I set forward on my course from said pine tree, a course due west according to my instructions, that is west ten degrees north, variation allowed per order of the governor and council; and the same night I measured 1 mile and 16 poles to Beaver River.

"Wednesday, April 15. We measured 6 miles and lodged on the bare ground. At the end of two miles we crossed a large stream running southwesterly. At the end of another mile we crossed the same stream, and 80 poles before we finished this day's measure we waded through a swamp almost to our middles in water.

"April 16 we measured to Hudson's River. On a small mountain 4 miles from where we began to measure we had a fair view of the city of Albany and at the same time had as fair a view of the falls of Mohawk River called Cohoos or Great Falls, above Albany, to our very great joy, and we named the hill Mount Joy, the said falls being distant from us 3 or 4 miles; from there we kept our course to Hudson's River at about 80 poles from the place where Mohawk River comes into Hudson's River. We went thence to Albany and tarried there that night. . . .

"We kept on our course until April 26.

"I purchased a canoe at Dunstable and we came down the Merrimack River to our homes where we arrived about nine o'clock after 37 days' journey, all in perfect health through God's great goodness to us."

Hazen's party numbered 8 men all told. Where is the engineer or party to-day that would undertake the task that lay before these men that twenty-third day of March, 1741, when they bade good-by to George Mitchell and his party at Boundary Pine? Their task was to run a straight line nearly 120 miles long, with an ordinary surveyor's compass, a rude instrument at

that, probably, 50 miles of the distance through an unbroken forest from the Connecticut River to Hudson River, and only partly settled from Boundary Pine to the Connecticut River; yet they accomplished this work in 5 days less than one month.

In Governor Belcher's warrant to Richard Hazen, we find the following words:

"And you are to take especial care in this your survey, that you faithfully spot the trees, standing in the said line, and make the best monuments you can besides."

Hazen in his report says that "owing to the snow he could make but few monuments," but spotted trees are good for a hundred years. When we made the preliminary survey of the Hazen line in 1891, we found an old pine tree lying partly down the west bank of the Merrimack River; on interviewing the owner of the land, Frank Bancroft, we found that this tree was the identical pine that Richard Hazen's men spotted on the twenty-third day of March, 1741. Mr. Bancroft informed us that it was standing and leaved out only three years before. There is no doubt about the correctness of the tradition.

The most careful inquiry failed to show that the location of the boundary of 1741 had ever been litigated in the courts of either state. Copies of Hazen's and Mitchell's maps were among the documents received from England in 1887, and we had them photographed for the Massachusetts Commissioners' Report of 1889.

Mitchell's work seems to have been fully as successful as Hazen's. We made a plat of our work on the same scale as Mitchell's map, and then made a tracing of our map. On applying this tracing to the Mitchell map, they were found to coincide with astonishing exactness, only a slight variation at Bradford neck being apparent. From the ocean to Boundary Pine is about 36 miles as the river runs; the area of the territory north of the river should then be 36 by 3-108 sq. miles. After completing our map of the river and boundary line on a scale of 2 500 ft. to an inch, we made a very careful estimate of the area between the north shore of the river and the line of the monuments, and we found 104 sq. miles in round numbers. Then we went over Professor Quimby's map in the same manner, the two measurements agreeing very nearly, and thus we demonstrated the accuracy of Mitchell's map in another way. Our map probably cost nearly, if not quite, a thousand dollars, but it is doubtful if Mitchell received a hundred for his work.

We come now to a brief consideration of the re-survey of the

New Hampshire line in 1825. It appears from the records that commissioners were appointed by both states to perambulate the line. Caleb Butler, of Groton, was appointed surveyor for Massachusetts, and Eliphalet Hunt, Esq., was appointed surveyor for New Hampshire. In the month of August, 1825, the commissioners with the surveyors met at Salisbury Beach, and retraced the Mitchell line and the Hazen line to Connecticut River. The commissioners for both states reported that they had found the Mitchell and Hazen lines substantially as they were run and marked in 1741. At a subsequent meeting of the commissioners the surveyors presented a protraction of the line run by Richard Hazen. It appeared from this plan and other statements made in the interest of New Hampshire that this line crossed the Connecticut River nearly 3 miles north of a point due west from Boundary Pine. The commissioners on the part of New Hampshire then proposed to the commissioners on the part of Massachusetts to run a new line in conformity to the original decree; but this proposition was peremptorily declined, our commissioners stating that they were only authorized to retrace the line of 1741. This difference parted the two commissions, and they never met afterwards. In 1827 the Hon. Benj. F. Varnum, of Dracut, who was Butler's assistant surveyor two years before, was ordered to erect the monuments on the Hazen and Mitchell lines, one at each Massachusetts town corner and one at each angle in the Mitchell line, marked "M S" on the south side.

At a point near Captain's Pond, in Salem, N. H., we found two monuments about 400 ft. apart, on the course from said pond to the northwest corner of Haverhill, and this fact led to our connection with the Massachusetts northern boundary survey. In order to solve the problem of these two monuments we went to the state records of Massachusetts. We found the reports of the Massachusetts and New Hampshire commissions of 1825 all on file and Butler's maps of the Mitchell line and the Hazen line. The two reports of 1825 showed conclusively that no boundary line between Massachusetts and New Hampshire had ever been established by the joint action of the two states. The facts being reported to the Haverhill city government, a petition to have the monuments recognized by both states was submitted to the Massachusetts legislature of 1883, but this was a failure. At the session of 1885 the Massachusetts legislature passed resolutions authorizing the governor, with the advice and consent of the council, to appoint three commissioners, to meet a

like commission to be appointed by New Hampshire to ascertain and establish the true jurisdictional line between the two states, and repealing all previous legislation inconsistent herewith. This proposition was accepted by New Hampshire, and John J. Bell, of Exeter; Nathaniel H. Clark, of Plaistow; and Col. Charles Roberts, of Concord, were appointed on the New Hampshire commission. October, 1885, Governor Robinson appointed Henry Carter, of Bradford; Geo. W. Cate, of Amesbury; and Nelson Spofford, of Haverhill, commissioners for the Commonwealth of Massachusetts. The first meeting of the joint commission was held in Boston, November 7, and the second meeting at my office in Haverhill, November 21.

The Massachusetts commissioners had assumed that, the line having been marked by the Varnum monuments since 1827, all that would be necessary would be to run the lines on the ground, between the monuments, and mark the road crossings, but they soon found that the old contest of 1825 was to be fought over again.

Mr. Bell's grandfather, Samuel Bell, having been chairman of that commission, the grandson must now follow in the footsteps of his predecessor, and he opened the controversy with the statement that the old king's decree of 1740 was just as valid and binding now as the day it was issued; that there was not then and never had been any legal boundary between the two states; that the decree of King George called for a line 3 miles north of the Merrimack River from the ocean to Boundary Pine, thence in a due west line to his Majesty's other governments; that Varnum set his monuments anywhere that he could dump them by a road side; that instead of being 3 miles from the river some were only 2 miles and some were about 4 miles; that the line from Boundary Pine to the Connecticut River crossed that river 3 miles too far north, taking from New Hampshire a large gore of land 58 miles in length averaging 1.5 miles in width; that consequently we must commence *de novo*, run a new line 3 miles north of the river, and a due west line to the Connecticut River from Boundary Pine.

Replying to this harangue the Massachusetts commissioners informed Mr. Bell that the old decree of 1740 was not worth the paper it was written on; that King George closed his real estate office in Massachusetts, June 17, 1775, and had done no business here since that date; that Governor Belcher appointed George Mitchell and Richard Hazen, under oath, to mark out the line on the ground, in accordance with the decree; that the work was

duly executed and accepted by Governor Belcher, the maps properly returned to the authorities that issued the decree, accepted and recorded, and the bills for that work had all been paid by New Hampshire, which then signified its acceptance of the work, and that the line thus accepted and recorded had been recognized as the line of jurisdiction by both states for the space of 140 years; that their work had been reviewed in 1825 by commissions authorized by both states, and both had reported that the original lines had been found, and that two years later, 1827, Hon. Benj. F. Varnum had been commissioned by the legislature of Massachusetts to erect the monuments on said lines; that the monuments as standing marked the line between the two states and that there the line must remain.

This question was argued pro and con from 10 A.M. to 9 P.M., and an agreement was finally reached to get the best available map of the Merrimack River and to survey the line as marked by the monuments from Boundary Pine to the ocean.

Shortly after, the writer resigned his commission and was appointed surveyor for Massachusetts, and Col George Whitney, of Royalston, was appointed commissioner to fill the vacancy.

Prof. E. T. Quimby, of Hanover, was appointed by the New Hampshire commissioners as surveyor for that state. He was to determine the distance of each monument from some point on the river by triangulation. With his assistant he camped at Reservoir Hill in Lowell, about the first of May, 1886, and went through to the ocean.

The Massachusetts party was to survey the boundary line by course and distance from monument to monument. At the commencement of our work the problem that presented itself was to run straight lines from monument to monument, nearly the entire distance being covered with tall pine trees, and to do it without the use of random lines. In the practical execution of that survey, we did some things not laid down in any treatise on surveying. As to how we accomplished this, we beg leave to refer engineers to our contributions to *Engineering Record*, December 10, 1904, also to our article on "Daytime Observations on the North Star," October 22, 1904, by which we determined the true course of every line from Boundary Pine to the ocean, and finally to our article in that paper, on "Steel Tape Measurements," published July 16, 1904. These three articles in the *Engineering Record* give the reader a pretty clear account of the field work of the survey.

Professor Quimby was stricken with paralysis December 17,

1887, and died February, 1890. Geo. W. Fernald, one of Professor Quimby's assistants in 1886, was then appointed surveyor for New Hampshire by the New Hampshire commissioners; but Mr. Fernald was taken sick soon after his appointment, and died without doing any work on the line. After the untimely death of Mr. Fernald, Ray T. Gile, of Littleton, was appointed surveyor for New Hampshire.

Previously to Mr. Gile's appointment the commissions of the two states had agreed upon the location of the eastern section and had agreed to make a preliminary survey of the western section. This survey had been commenced at Boundary Pine in October, 1890, but in consequence of Mr. Fernald's sickness the work was discontinued at Long Pond, October 18. It was resumed by the writer in company with Mr. Gile and two axmen at Long Pond, April 23, 1891, and continued through to the Connecticut River.

This survey developed the fact that there was no question about the line of jurisdiction; for, besides numerous monuments and wooden fences, we found 14 miles of solid stone wall, some of it 4 ft. thick, on the line of *jurisdiction*. Our instructions were to run our line as nearly as convenient to the line of jurisdiction, but not to follow it in any instance. We ran one straight line 21 miles, and the measurement came within 6 ft. of Borden's triangulation work. The measurements were all made with a 300 ft. steel tape, the contacts all being made on vertical plumb rods, kept in position by 2 assistants with stay rods.

This preliminary survey closed in August, Mr. Gile returning home, while our party immediately commenced setting the monuments on the eastern section. September 10, 1891, at 12 o'clock M., the joint commission met at Salisbury Beach to mark the extreme northern point of the Commonwealth of Massachusetts, and set the first monument ever placed on the Massachusetts and New Hampshire line by the joint action of the two states. This is a tablet on a ledge in the marsh, called "Major's Rock," where Simeon Borden set his copper bolt in 1836. The tablet is 3 ft. square and 1 ft. in thickness, with a circular conical opening through the center, showing the copper bolt just as he left it. The tablet was set in Portland cement, and secured to the ledge with 2 copper bolts 2 ft. in length leaded to the rock and to the tablet also. The tablet is made of New Westerly granite, polished on the top and west and south edges. There are some 400 letters and figures on the upper surface, and on the southerly edge letters and figures showing the latitude and longitude of this station.

Our party was occupied in setting the monuments from the 27th of August to the last of November in 1891. The Boundary Pine monument is 18 by 18 in. and 9 ft. long, set 4.5 ft. in the ground, cut from New Westerly granite, the same as the Major's Rock tablet, all four sides polished and lettered the same as the tablet, substantially, with the addition of the cut of a pitch-pine tree on the eastern face. All the other monuments, 63 in number, are of ordinary light-colored granite. Those at the angles in the line are 16 by 16 in. and 8.5 ft. long, set 4.5 ft. in the ground, while the road crossing monuments are 14 by 14 in. and the same length. Margins 2 in. wide are cut on the corners, and two opposite sides are hammered 2 ft. down from the top, and properly lettered.

In the work of surveying and monumenting the Mitchell line, no attempt was made to straighten any course, but we followed the resolve of 1885 to ascertain and establish the true jurisdictional line. At South Hampton, N. H., it appeared that the straight line between two adjacent monuments was not the line of jurisdiction. The straight line from monument to monument passed west of the dwelling house and outbuildings of Mrs. Rebecca Palmer, while the owners of this place had always been residents of South Hampton. Consequently we set a new monument, and thereby followed the line of jurisdiction.

On the line between Haverhill and Plaistow it appeared that a straight line from Lover's Lane to the Foot monument would pass directly through the dwelling house of Nathaniel H. Clark, of Plaistow, one of the New Hampshire commissioners, and would leave his residence in the city of Haverhill. But Mr. Clark didn't see it; he said the state line had always passed on the south side of his house, near a certain elm tree, and it must stay there, and we moved the Foot bound 150 ft. south so as not to disturb Mr. Clark.

These two cases disposed of, there was no other place where straight lines between monuments appeared to differ from the line of occupation, and at the close of our work, December 2, 1891, 36 miles of the Massachusetts northern boundary had been established and monumented, never to be questioned by any court thereafter, all the work of this section having been completed and ratified by both commissions during the lifetime of the original commissioners, although only one of the original commissioners signed the final report in 1899.

Coming now to the western section; after the death of Mr. Bell, which occurred August, 1893, Hon. J. G. Bellows, of Walpole,

was appointed to fill the vacancy, and during his administration the monuments were erected on the western section of the Hazen line. The new chairman of the New Hampshire commission and the surveyor caught the straight line fever and had it in the natural way. Let us see what they did. On page 24 of Commissioner Bellows' report, after rehearsing what the two commissions had separately conceded, he proceeds as follows: "The commissioners on the part of both states, for the purpose of arriving at a settlement of all disputes, agree on the present line of occupancy, as the boundary line between them." How could anything be expressed in the English language more clearly than this, exactly what the joint commission had been executing in the work of surveying and monumenting the eastern section? Then the agreement proceeds: "Said line to be ascertained and run as follows:" How? By the 14 miles of stone wall on the line of occupancy, and various fences and road monuments which had been recognized as the line of jurisdiction from the day that Hazen's men spotted the trees? Not at all. The next paragraph of their agreement read as follows: "This line to be ascertained and established by running straight lines between adjacent town corners." The principle upon which the surveyor and the joint commission had established the eastern section of the line was to be completely ignored on the western section. Instead of making the line of occupancy the boundary line as they had agreed, these savants were to run a new line from Boundary Pine to the Connecticut River. Notwithstanding that they were forcibly reminded that two states are not competent to change a state line, that that was the business of the United States Congress, they went ahead with their straight line scheme; and surveyor Gile went with the crowd.

Now witness the result. Not a mile of the 14 miles of stone wall is now on the line monumented, but a strip of neutral territory, from 0 to 250 ft. in width, extending in sections from Boundary Pine to Connecticut River, is left for a bone of contention. No taxes can be collected, nor can any criminal be arrested, on this neutral territory. No officer from Massachusetts can go north of the line established by this state. No officer from New Hampshire can come south of the line established by New Hampshire, no matter whether it is legal or illegal.

No state, county or town can repudiate its own work. It is at once and forever estopped from that. If the joint commission

had presented its correct work to Congress to be ratified and Congress had accepted it, then the line monuments would have become the legal boundary. As it is, the Hazen line is the only legal boundary, and the joint commissioners' line is bogus, null and void, although accepted by both states.

A brief consideration of the salient points in the Vermont boundary controversy will close this paper.

It had been discovered by the preliminary survey of the western section of the New Hampshire line that the monument originally marking the southwest corner of the New Hampshire line had been undermined by the freshets in the river, and the point was apparently lost, hence the necessity of a Vermont commission. At the October term of the Vermont legislature for 1892 commissioners were appointed to join with Massachusetts and New Hampshire in fixing the southwest corner of New Hampshire and the southeast corner of Vermont, and near the end of the session the governor appointed three lawyers on the commission, Kittredge Haskins, L. M. Reed and J. K. Batchelder, but delay seemed to be the order of exercises with this commission. They never met the other commissioners until July 28, 1893, then adjourned until August 10. At this meeting at Brattleboro, the Vermont commissioners presented Volny G. Barbour, professor of civil engineering, from the Vermont State University, as surveyor for Vermont.

A reconnoissance of the line was ordered to be executed by the surveyors, to commence August 20, when we met Professor Barbour at Taconic Inn. The next day, Monday, August 21, the late Surveyor Walker, of Williamstown, Mass., piloted us to the northwest corner of Massachusetts. Then we passed over the line as shown by Mr. Walker and others, until Friday, 6 P.M., when we returned to Brattleboro. At this meeting it was decided to make a triangulation survey of the existing monuments on the line, Professor Barbour's scheme. Thursday, September 5, we commenced the triangulation work at northwest corner and closed at South Vernon, Saturday, October 21.

I was well aware of the difficulties of the work before we commenced the survey. Our work was based on Borden's triangulation work of 1836. Professor Barbour adopted for his base line Borden's Greylock–Jilson, about 85 000 ft., or 16 miles. The Borden stations were all accessible; the difficulty was in locating the town corners from Borden's points. At one place to reach a corner we were obliged to run a traverse about 2 miles long including three base lines and a multiplicity of

angles and triangles. Professor Barbour made a brief report at a meeting of the commissioners in Boston, February 9, 1894. In this report he stated that the triangulation map was made to locate the fences and other marks along the supposed state line. Town corners were not mentioned at all, nor Borden's Leyden, nor his Jilson, while he took Borden's Greylock–Jilson, about 16 miles, for his base line for his triangulation survey in 1893.

This little diversion cost the state of Massachusetts some $3 000; and then, to cap the climax of absurdity, when the commissioners met at Brattleboro, June 20, 1894, it appeared that the Vermont commissioners and surveyor Barbour had caught the New Hampshire straight line fever. The Barbour town corner triangulation survey and our maps were relegated to innocuous desuetude, the Vermont commissioners having given Professor Barbour express direction not to locate any town corners, after thousands of dollars had been expended and about three months' time lost in the triangulation work inaugurated for the sole purpose of locating all the town corners. The Vermont scheme was to run a straight line from northwest corner to Jilson, 19.5 miles, thence to Belding, at Connecticut River, 20.5 miles, regardless of the line of jurisdiction. On mapping this scheme it appeared that the line from Jilson to Belding would pass some 1 200 ft. south of the residence of Geo. H. Phillips, Esq., of Colrain, Mass., transferring Mr. Phillips to Halifax, Vt. When the commissioners were informed that Mr. Phillips was not going to Halifax, commissioners or no commissioners, this ideal straight line had to be chopped up and made into 4 lines, northwest corner to South Jilson, 19.5 miles; South Jilson to Phillips, about 5.5 miles; Phillips to Leyden, about 6 miles; Leyden to Belding, about 9 miles.

The work of running these lines on the ground was not commenced until August, 1896. Professor Barbour claimed that he should run the line from northwest corner to South Jilson. Our party ran one continuous line from Belding to Jilson, 9 miles, cut it out, measured it with a 300 ft. steel tape and plumb rods, and located all the town corners, intersecting only one on the entire 20.5 miles. Professor Barbour intersected one old road crossing monument, and that was all. The work of erecting the monuments was commenced immediately after the close of running the line. Professor Barbour's party set the monuments on the 19.5 mile section, our party set them on the 20.5 mile line, all of light colored granite, 14 in. square and 8.5 ft. long.

September 9, Professor Barbour notified me at South Vernon that he would be ready to set the new monument at northwest corner the next day. We all met there the next day about 10 o'clock, the New York party coming later.

Borden had written in his daily journal, dated September 24, 1836, as follows:

"Morning rainy, employed in writing; afternoon cleared up, when we took the stone I had prepared for a monument to the corner of the state and erected it in the place where the post had formerly stood, finding some of the decayed post when digging.

"The stone which we erected is of marble, about 5 in. square, and appears above the surface of the ground about 2 ft."

At the 1897 session of the Massachusetts legislature a resolve was passed authorizing the Massachusetts Topographical Commission to join the New York state authorities in a review of the Massachusetts and New York boundaries. This resolve specified that the surveyors were to run and monument the true line between the territory under the jurisdiction of the Commonwealth of Massachusetts and that under the jurisdiction of the state of New York, but the surveyors thought that as the original line was straight it should be made straight now; so they ran one straight line 41 miles long from Alandar Mountain to the Vermont line. This new line failed to intersect the Massachusetts northwest corner monument, and then the Massachusetts commissioners discovered the astonishing fact that the northwest corner of Massachusetts had been in the wrong place for over 150 years. Here was a dilemma indeed; but these surveyors were equal to the emergency. They took up our Barbour monument, and moved it over the state line into the town of Petersburg, in the state of New York, so that when the Massachusetts and Vermont Commissioners undertook to fix their line, they commenced the description at this removed monument, and consequently, by the record now, the northern boundary of Massachusetts starts in New York state, and runs some 60 ft. before it intersects the northwest corner of Massachusetts. These parties justified their work on the plea that the northwest corner of Massachusetts had been in the wrong place over 100 years, and this plea was sanctioned by the Massachusetts commissioners, the very parties that had fought Bell from 1885 until he died in 1893, on the ground that the monuments marked the line.

The same doctrine was carried out by those two distinguished men, Daniel Webster and Lord Ashburton, in the

northeastern boundary dispute, where they found a monument near Rouse's Point about a mile out of line, but they didn't move it. Again, about 1879, New York and New Jersey reviewed their boundary; what was supposed to be a straight line 50 miles long was found to be deflected to the south, near the center of the line, 4 900 ft., but New Jersey didn't ask to have it relocated. Once more, at the same time, 1879, the New York and Pennsylvania line was reviewed, which was originally intended to be on the 42d parallel of latitude, but the reconnoissance showed that no part of it was on that parallel, and that hardly any three monuments were in the same straight line, these having been originally placed at the end of every mile. The commissioners for Pennsylvania wanted the line corrected, and placed on the 42d parallel, but the New York commissioners said nay.

This boundary line was fixed in 1787 by David Rittenhouse, the best surveyor, mechanician and astronomer there was in the whole world at that time, and the monuments that he caused to be erected had marked the line of jurisdiction between the two states from that hour. Consequently, whether straight or crooked, that line must remain the boundary between the two states, and there it is to-day.

When Mr. Bond, the New York State engineer, came before the New York legislature with his straight line, all monumented, the legislature didn't see it. It refused to go back on its own record, Mr. Bond had leave to withdraw, and the parties that his straight line transferred from New York to Massachusetts still vote in New York, and they will be pretty likely to remain there. What becomes of the Massachusetts record, with some 60 ft. of the northern boundary projecting over the state line into New York? This *faux pas* has been enacted and placed on record in our state archives. Must not this law be repealed and the whole record expunged? Owing to the removal of the Barbour monument, to-day there is not so much as a birch stake on the ground, to indicate the northwest corner of the state.

The Massachusetts commissioners, Messrs. Savage, Cate and Hodgdon, seem to have taken their cue from Professor Barbour, as on page 3 of their report, dated January 19, 1900, we find the following statements:

" No official monuments had ever been erected on the Vermont line, except at the northwest corner of Massachusetts a small stone had been placed in position, to mark the bound, and a Varnum monument on the west bank of the Connecticut River,

*but there were no monuments between these two points.* A state boundary line 41.5 miles long, that had limited jurisdiction for 150 years, had no marks on the ground, only at each end, and no question as to its location had ever been before the courts of either Massachusetts or Vermont."

How did we locate and map 15 town corners if there were no monuments on the line? We found 5 town corners and one road crossing marked with slatestone monuments from 1.5 to 3 ft. high, and stakes and stones and fences mark the others, and one road crossing was most emphatically marked by the northern end of Esquire Phillips's house.

No joint report on the Massachusetts and the Vermont line was ever written by the surveyors for those two states, and no map made by either of the surveyors was ever seen by the legislature of either state, and no map of the line was ever made by Professor Barbour.

A glance at any ordinary map of Massachusetts shows about 100 miles of the northern boundary as an absolutely straight line. In the last half of Professor Barbour's report he goes into a lengthy dissertation on his straight-line scheme, asserting that a straight course from Boundary Pine to northwest corner would cross Connecticut River 300 ft. south of Belding, the point where Hazen crossed in 1741, but upon applying a straight edge to Borden's large map the fallacy of this statement was apparent. Borden had no less than 7 of his triangulation stations from Boundary Pine to northwest corner with their positions all determined by that master of mathematics, and all of them but Boundary Pine on high ground. But having all the measurements and courses from the true meridian, as determined by day-time observations of the North Star, we mapped the north line of Massachusetts from Boundary Pine to northwest corner on a much larger scale than Borden's map. This line, barring slight irregularities, resembled very closely the curve of a parallel of latitude, whereas the straight line passed 900 ft. north of Belding, instead of 300 ft. south of it as Barbour had stated. This led to a discussion in which he contended that a straight *course* and a straight *line* were not synonymous terms, but what bearing could that straight line question have on the fences and other marks supposed to indicate the Massachusetts and Vermont state line?

There we left it, Professor Barbour dying June 4, 1901. In his death the Vermont University suffered an irreparable loss. He was a useful and much respected citizen, a perfect gentleman

in his deportment, and the idol of the students in the class room. Whether Professor Barbour was the originator of the straight-line boundary scheme, or whether that was the invention of the Vermont commissioners, I never knew, but these commissioners gave the surveyors instructions not to notice town corners or to make any ground measurements; notwithstanding this injunction, our party cut out the line from Connecticut River to Jilson Hill and measured it with steel tape and plumb rods in the same manner as we had measured the line from the said river to the ocean, and on our own responsibility we procured and set town corner monuments on all the Massachusetts town corners as far as Jilson, and later the Massachusetts commissioners ordered all the Massachusetts town corners on the Barbour line monumented.

While the state of Massachusetts had been expending from $10 000 to $20 000 a year during the past 10 years for the purpose of locating town corners by triangulation, these Vermont Boundary Line Commissioners, three lawyers, totally ignored all the town corners on their state line, and forbade their surveyors marking any of them. These Vermont commissioners, after their straight-line scheme had changed the entire 41.5 miles of the state line and left all the town corners with nothing to indicate their location on the new line, coolly informed us that they were making things certain which were before uncertain. They seem to have got their dictum wrong end up, and have actually made things very uncertain which were before certain. The simple fact that there has been no dispute over the location of the state line for more than a century and a half settles this question most effectually. After an expenditure of some $54 000 by the three states, about 100 miles of it are in a much worse condition to-day than before the recent commissions were authorized.

## DISCUSSION.

Mr. Frank W. Hodgdon (*by letter*). — Much of the paper is devoted to describing the manner in which the line should have been marked in the opinion of the author rather than as it was actually run out and marked by direction of the commissioners appointed by the three states for doing the work, whose work was later approved by the legislatures of the three states.

In the early part of the paper he says that the New Hampshire boundary line had never been established by the joint action of the two states, while later in the paper he says, two states are not competent to establish the boundary line.

He also says that there is a neutral zone lying between two lines over which neither state can exercise jurisdiction, but as both states have agreed to the same line it is difficult to see how there can be any neutral zone between them.

Having been one of the Massachusetts members of the commission which made the final report establishing this line, and having, so far as I was able, obtained all the information which could be secured in relation to the methods of running out and marking the line, a short statement of the way in which the line has been established, marked and re-marked may be interesting.

After much mutual misunderstanding in relation to the northern boundary of Massachusetts, the King and Council in 1740 fixed the line as 3 miles north of and parallel with the northerly bank of the Merrimack River from the sea to a point 3 miles north of Pawtucket Falls, now Lowell. From this point the line was to run due west to his Majesty's other possessions. This line was run out and marked by blazing trees under the direction of the governor of the provinces of Massachusetts and New Hampshire.

No further marking of the line was done by state authority until 1825 to 1827, when the line was re-examined by commissioners from both states, who reported that they had found the line as marked by the surveyors in 1741, and along this line stone bounds were set by a surveyor employed by Massachusetts, New Hampshire taking no part in re-marking the line, but her commissioners reporting jointly with the Massachusetts commissioners that they had found the line as marked in 1741.

No further investigation of the line by the authorities of both states was made until the recent commission was appointed in 1885, although in the meantime, when the survey of the state was made by Mr. Simeon Borden, certain bounds were set by him to mark a few points on the line. It would not appear that he had any authority to set bounds which would represent anything else than his individual opinion as to where the line was. During this period, also, various other bounds had been set along the line and many stone walls built supposedly on the state line, but these were placed and constructed without authority from either state and were principally for the purpose of marking property lines and the intersection of town boundary lines with the state line.

When the recent commission made its survey of the line it identified to its satisfaction practically all the angle points in the line between the sea and Lowell, as marked by the surveyors in 1741 and 1827; westerly along the straight portion of the line

it found many of the bounds set in 1827 and decided that in its opinion the nearest approach which they could identify to the line as originally run out was a line connecting the bounds marking the various town corners along the state line, most of these having been set by the Massachusetts surveyor in 1827. The variation from the straight line can be readily accounted for by the comparatively rough character of the instruments used in running out the line originally.

The border between Massachusetts and Vermont had never been examined by any state authority, so far as I can learn, since it was originally run out in 1741, and there were practically no marks made at that time which could be identified by the recent commission. For this reason a different and somewhat arbitrary scheme had to be and was adopted. From all the facts obtainable the commissioners were satisfied that they had re-marked the line substantially as it was originally run out. The author of the paper, who was surveyor for Massachusetts, did not agree with the decision of the joint commissioners, his argument being largely that the line should follow the property lines established by individuals rather than the marks fixed by state authority. The principle of law is well known to all surveyors that in a description of land a bound on the ground should be accepted as marking the line rather than a course and distance given in a deed, but the bound must have been placed by some competent authority, and in this case the only bounds placed by competent authority were the trees marked by the surveyors in 1741 and the bounds set by the Massachusetts surveyor in 1827. Property owners and local authorities, while intending to conform to the true line, frequently took inadequate measures for determining the line. A case which came to my knowledge recently was where the local authority of an adjoining state extended the town water pipes across the line to supply a number of houses on the Massachusetts side of the line, thinking and believing, so far as I was able to learn, that the buildings in question were on the other side of the line, — the buildings and land on which they stood being taxed by the town in the adjoining state. In this case no attempt had been made to accurately run out the line, but local opinion that the line was beyond the houses in question was relied upon. The question of necessity of action by Congress does not arise in this case as no attempt has been made to establish a new line, but simply on the best information obtainable to re-run and re-mark the line as originally fixed by decree of the King.

The same is true of the western boundary of Massachusetts.

the portion of which from Alandar Mountain to Vermont was re-run and re-marked as nearly as could be done on the line originally laid out in 1787, many of the original monuments being found and the line passing within 2 or 3 in. of all permanent marks found and through many of the stone piles, generally within a few feet, never more than 4 ft. from their centers. As along the northern boundary, many walls and bounds had been set by owners and town officers which were found at considerable distances from the line as run out. As no re-marking had been done by state authority since the original marking in 1787, these bounds and property fences were not considered in the final location, enough of the original marks having been found to identify the location of the original line throughout its whole length.

In regard to the northwest corner, no evidence was obtained that the small bound found there, said to have been set by Simeon Borden, marked any point in either the survey of 1741 of the northern boundary or the survey of 1787 of the western boundary; and as it did not agree with the other marks practically identified on the western boundary the intersection of the two lines as determined from the investigation of the various commissioners was fixed as the corner of the state rather than the point marked by the Borden monument.

All the lines as re-examined and re-marked in recent years have been adopted by the legislatures of the respective states as marking the true line, excepting the boundary between Massachusetts and New York. This has been accepted by Massachusetts and it is expected that it will shortly be accepted also and adopted by New York, when the facts become fully known.

In the 27th Report of the Massachusetts Harbor and Land Commissioners for the year 1905 there is, on pages 46–62, a summary of the history of the monumenting of the state boundaries, near the end of which it is stated as to whether or not an act of Congress ratifying the action of states in delineating a common boundary line is essential to the validity of the jurisdiction so determined, that

"it would seem that an agreement or compact between two states, which, in establishing a boundary line, set over or interchanged inconsiderable areas for the purpose of straightening or more clearly indicating the same, the effect of which bore upon property rights only, and had no tendency to change the power or political relationship already existing between the states themselves or in their relationship to the United States, would not be repugnant to the Constitution or require the confirmation of Congress."

[NOTE. Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by November 1, 1906, for publication in a subsequent number of the JOURNAL.]

## FIRES AND THEIR PREVENTION IN FACTORIES.

By F. B. Sanborn, Member of the Boston Society of Civil Engineers.

[Read before the Society, June 20, 1906.]

Ten years ago the magnitude of fire losses in this country was about 140 million dollars each year. Five years ago the annual losses amounted to about 160 million, and for the year 1905, 175 million. These have been average years, and it will be noted that the losses have increased from 140 million to 175 million during the period of ten years. Inasmuch as the country has been increasing in wealth and prosperity during this period, the increase in losses is little more than proportional to the whole growth of the country. But the discouraging feature is that the aggregate amounts for the succeeding years have not been materially reduced, even lessened by one half.

The present averages, 150 to 175 million annually, have been greatly exceeded one year during the past ten, namely in 1904. In that year occurred the great Baltimore fire, and the annual loss rose to 230 million. That fire occurred in February; and December 30 preceding came another serious fire, namely the Iroquois Theater holocaust; and in the June following occurred a third fire of equal horror, namely, that of the excursion steamer *General Slocum* in New York Harbor. These three fires, Baltimore, Iroquois, *General Slocum*, considered in conjunction with the recent devastation at San Francisco, form four important object lessons of which I wish first to speak briefly.

The Baltimore fire burned through the business part of the city, an area about 0.25 mile wide and 1 mile long. The fire lasted 30 hr. and consumed about 70 million dollars worth of property. Contrast this fire with that of the

Iroquois Theater: Here, instead of 30 hr. as at Baltimore, the fire lasted 30 min. Instead of 70 millions loss, an insignificant amount. Instead of 1 person killed, 588 persons were killed and 250 injured. Baltimore taught the lesson anew that sweeping conflagations are possible even in modern cities; and Iroquois showed the awful destruction of human lives that is imminent in many theaters and auditoriums.

A different but equally impressive lesson was shown by the *General Slocum* fire that occurred about this same time, namely, on June 15, 1904. This excursion steamer was carrying a German Lutheran Sunday-school; about 1 200 passengers. Of this number about 960 were lost by the fire and by drowning — not on the open seas, but within hailing distance of the shores of greater New York; in fact, near the very spot where, 24 years previously, another steamer met a similar fate. Yet the burning of the *Slocum* is said to have been the worst harbor disaster that has been recorded in the history of American catastrophes.

The story of San Francisco is fresh in our minds. Beginning the morning of April 18, 1906, earthquake and fire wrecked some 3 sq. miles of the business section of the city. The total monetary loss attributable to the fire is, at this time, difficult to estimate and will ever be only approximate on account of the indeterminate destruction that was wrought by the earthquake. Present estimates place the loss that should be charged to the fire as 200 million dollars. Undoubtedly this has been the greatest conflagation in our history. With water mains broken, little resistance could be offered by the fire-fighting facilities. City steamers were used intermittently and buildings razed to the ground by dynamite, but the conflagation once well under way swept on until vacant lots, wide streets or opposing forces of wind could stop it. Some reporters have stated that around the city the atmospheric conditions were calm and normal, but within a roaring furnace created a gale of wind and cross currents that swept inward and upward. A noteworthy feature of this San Francisco catastrophe has been the remarkable fortitude and splendid courage shown by thousands of homeless citizens. Now that the worst is over these valiant people have opportunity to show our American communities a second object lesson, namely, a city of modern construction and with improved fire protection; better than our average American city; better than our new Baltimore.

When we stop to consider three great fires and the sum total of annual losses the question arises how to prevent such sweeping conflagations, how to reduce the total annual loss by one half. A method that was started 70 years ago, and which has been successful in factories, is one that I desire to speak of in the following paper.

Beginning with a few cotton mills in Rhode Island the

system has extended until now it includes, in one form or another, most of the leading manufacturing plants of the middle west and the southern and eastern states. The largest of these factory associations is the Factory Mutual system. This system now comprises about 2 500 factories. The total insurable value represented is about 1 billion, 2 hundred million dollars ($1 200 000 000). The system extends through Canada, the New England states, New York, Pennsylvania, Ohio, Indiana, Illinois, Wisconsin and nearly all of the Southern States.

The engineering and inspection departments of these associated companies have been brought to high standards of organization and serviceableness by the foresight and notable perseverance of our fellow member, John R. Freeman.

Four essential elements are made pre-eminent in forming an estimate of these factories: Good general order and neatness, good construction (combining with that, construction to overcome exposures), safe occupancy and reliable fire protection. These four conditions, order, construction, occupancy and protection, together constitute the quality of the fire risk as a whole. There are, however, bound to be variable conditions among different factories. In construction there are the light joisted buildings of the Middle States, and older mills of New England, the brick and steel girder floors of some silk and jute mills, the heavy plank and timber floors and roofs of modern mills now common in North and South, and a few of the new style concrete plain and reënforced.

In occupancy the conditions vary from the crowded miscellaneous manufactures of a single building in which are made upholstery, jewelry, plush, paper boxes, dress goods and men's wear, to the building with product plain and simple of unfinished iron castings.

The protection, furthermore, as will be easily understood, is the most variable of all. From the mill, located miles away from any fire department, which boasts that fire pails " skillfully applied " are ample to save that " particular mill " from any fire that can start, to the modern equipped mill with chemical extinguishers, automatic sprinklers, hydrants, hose, elevated tank, city water, special pumps and private reservoir. This disparity in order, construction, occupancy and protection of different factories can only be kept to a minimum by some system common to all, and effectively sustained. This is done in the aforesaid factories through the medium of insurance companies with their systems of frequent inspections, supple-

mented by cheaper insurance, prevention against business interruptions and losses that always result from any serious fire.

Any wise manager quickly discerns the advantages of lower rates of insurance and uninterrupted business, and he will adopt reasonable requirements for safeguards when convinced of the value of them, but some means must be employed to present those requirements, whereby one factory will be placed on a par with another. This requires a corp of engineers and inspectors who are employed in investigating the many phases of fire prevention and means of reducing fire hazards to a minimum. In the Associated Factory Mutual Companies there are 14 regular inspectors constantly going through factories; and so extensive has this system become that for any one inspector to complete the whole circuit of factories and return to his starting point requires 4⅔ years.

I was employed in this work for 7 years and recently during summer months, and I venture to say a word about the inspection work, leaving the subjects of costs and savings in insurance that accrue by adopting improved construction and fire protection to another speaker.

The primary duty of an inspector is to compare one mill with another; to point out defects; to suggest improvements; to examine all conditions that affect the probabilities of a serious fire. Is there likely to be a fire? Where? Of what magnitude? What are the most practicable means of avoiding a fire?

At each mill he visits he is required to fill out a report. This report will indicate his judgment of the general order and neatness, the condition of oily waste, fire doors, fire hose, mill fire brigade, electric equipment, automatic sprinklers, yard hydrants, fire pumps, public water supplies, building construction, occupancy and general fire protection. Then at the end he gives his estimate of the risk as a whole.

In order to fill out these inspection sheets accurately and with good judgment, the inspector must go through the property from top to bottom and see all items that in any way affect the good or poor qualities of the property as a fire risk.

He will usually begin at the top of a group of buildings, slowly walk through all rooms in company with some representative of the mill and examine as he goes along the general order; the occupancy in regard to machinery, stock in process, the amount and in a general way its value, the system of fire protection, which will include fire pails, small hand hose, automatic sprinklers and perhaps special devices like chemical extinguishers,

steam jets, rubber blankets and so on, noting on his sheet those items that go to make up his estimate of the top story of the factory. He proceeds downward through each story, looking at fire doors, fire shutters, sprinkler valves, construction of floors, thickness of walls, just as he has done in the room above. In the basement he will often find more to examine with special care, because here may be stored machinery, yarn in cases, cloth in bales, sometimes cotton or wool; the rooms are not so well lighted and there is apt to be less open space for operation

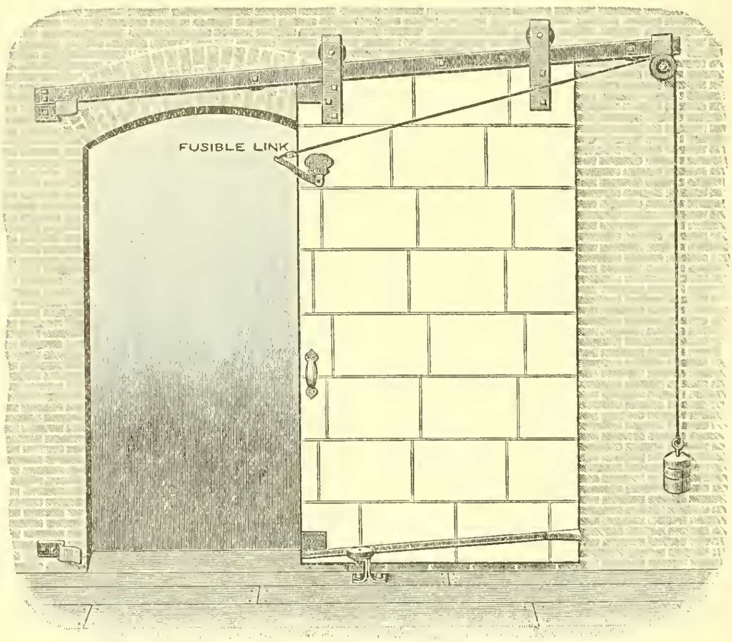


Fig. 1. A Standard Self-Closing Fire Door on an Inclined Track and with a Fusible Link.

during a fire. Here are, too, in the older mills usually, some of the main shut-off valves on 4- and 6-in. sprinkler pipes, which must be examined carefully in order to report positively whether they are open or shut; because, as will be evident, if one of these main valves becomes closed, as I have many times found to be the case, the whole protective system of sprinklers and hose throughout the building is cut off from its water supply.

Having finished his examination of the main group of buildings, he passes through the other buildings in the yard, which comprise storehouses, sheds and often boiler houses,

repair shops and certain classes of rooms with dangerous occupancy, as, for example, those that contain oils, rag pickers, gas processes, waste bins. In regard to this variety of occupancy he must judge of the special dangers of each. If any compartment of the storehouses contain over $100 000 worth in value, that fact should be noted. The protection afforded these disconnected buildings should vary directly as the value and increased hazard; that is, large values, $100 000 for example, should have automatic sprinklers in nearly every case with yard pipes ample for delivering good supply to the sprinklers and affording 6 to 8 standard fire streams from hydrants. Or if the building and contents are likely to burn quickly, they must be well isolated and it must be possible to smother the fire by adequate protection.

In order to judge properly of the efficiency of the protection, the inspector makes an actual test once every year. This test comprises trial of the fire pumps at their full capacity with delivery of water through lines of hose attached to the hydrants. The engineer or mechanic at the mill runs the pumps as hard as he would attempt to run them during an actual fire. The inspector notes the water pressure at the pump, the number of revolutions, length of stroke, smoothness of action, horse-power of boilers or water wheels that furnish the power and then in the yard at the hydrants the lengths of hose lines, sizes of nozzles and pressure that is being maintained at the hydrants. From these data he can compute the gallons of water delivered per minutes and make up his estimate of the general condition of the pump service. He then tests the city water supply and by proper gage readings can also estimate the number of fire streams that would be available from this source, because his final report must include a reliable estimate of the total number of fire streams that he considers to be available from pumps, public water and city steam fire engines combined.

The usual method of measuring the quantity of discharge from pumps or city water pipes is by observing the pressure, while water is being delivered through fire streams, by a gage screwed into a hole tapped in a hydrant or attached to a nozzle plug as shown in illustration. The pressure thus taken at an average hydrant serves for the 4 or 6 streams that are usually in operation. Then by referring to Freeman's Fire Stream Tables the discharge is determined. This method of using the hydrant pressure by which to determine the discharge permits of probable errors of 5 to 10 per cent. due to uncertain conditions

of the inside surface of hose. But by the device shown in Fig. 2 the pressure can be read directly at the nozzle. This device can be applied to a stream without shutting off the flow and without fastening any attachments to the nozzle; the weight of the gage and a slight pressure from the hand are sufficient to keep it in place at the tip of the nozzle, while the pressure is being read.

The essential parts of this nozzle piezometer are: A bent tube, acting as a Pitot tube, that transmits the pressure; a divider having knife edges that cut the water; and a shield that prevents the water from spattering seriously. I experimented with my first form of this device last summer while inspecting factories and testing pumps and water supplies, and during the past few months further experiments have been made by one of our Tufts engineering students (Mr. N. E. Hadley) with a view to determining the accuracy and practicability of the device.

As to accuracy for different positions in which the piezometer may accidentally be placed we have found that the pressure remains constant for all positions in the streams until the very edge is reached, so that with this size of tube practically only the full pressure can be read.

An advantage in taking the pressure at the nozzle instead of taking it at the hydrant lies in the fact that friction losses in long lines of hose are thereby eliminated.

Last summer at a test in a mill yard at Fitchburg, Mass., I found that with 400 ft. of linen hose and 1.25-in. nozzle a hydrant pressure of 146 lb. afforded only 43 lb. on a nozzle piezometer. This loss in pressure from 146 lb. to 43 is at first thought surprising, and although fire stream tables indicate this amount of loss it cannot be fully appreciated until actually observed, as is done when the pressure is taken at the nozzle instead of at the hydrant. Also it is nozzle pressure that really tells the force and effectiveness of the stream.

Besides its use for testing purposes this device may be found to have practical value in fire departments for taking the pressure that fire streams have at time of fire. Because of the lack of such record after a fire there are often many futile arguments as to the pressure that streams really possessed during a fire. In order to indicate the number of gallons flowing through given sizes of nozzles I have designed a gage dial that has inside graduations for pressures in lbs. per sq. in. and outside graduations for reading directly the discharge in gal. per min. for a given nozzle.

FIG. 2. GAGE DIAL AND NOZZLE.

FIG. 3. STREAM, AND MAN STANDING ON HOSE.

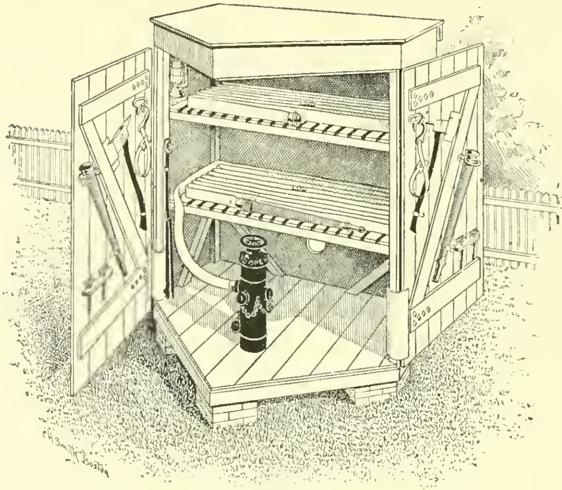

Fig. 4. A Hose and Hydrant House with Full Equipment: 200 Ft. of Cotton Rubber-Lined Hose, 2 Bars, 4 Spanners, 3 Playpipes, 2 Ladder Straps, 1 Nozzle Holder and 1 Heavy Mill Lantern.

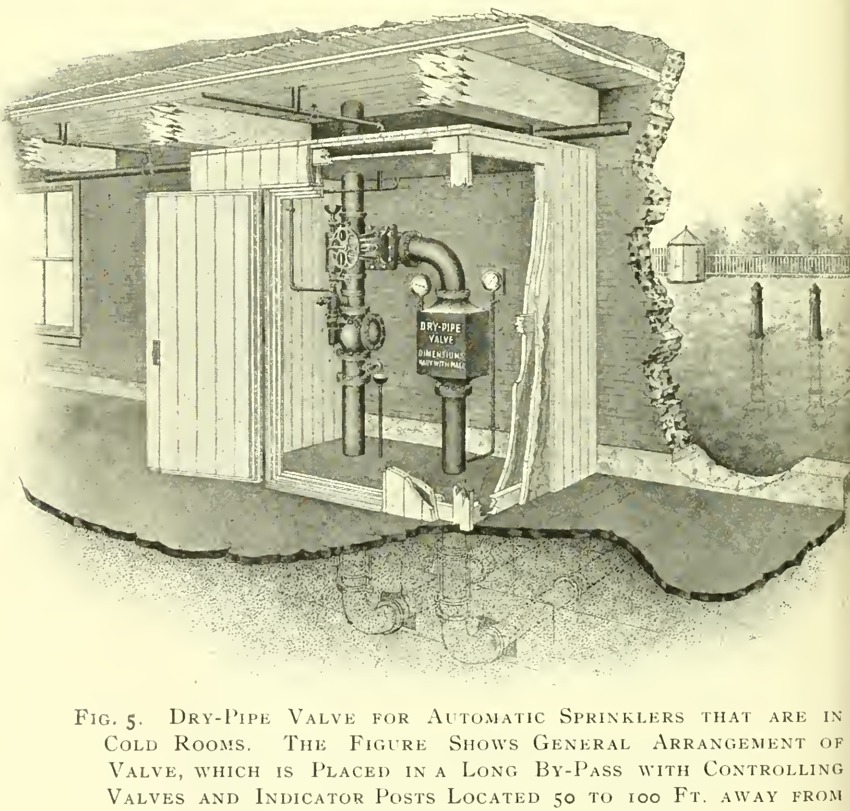


Fig. 5. Dry-Pipe Valve for Automatic Sprinklers that are in Cold Rooms. The Figure Shows General Arrangement of Valve, which is Placed in a Long By-Pass with Controlling Valves and Indicator Posts Located 50 to 100 Ft. away from Building so as to be Accessible during a Fire.

TEST OF THE ACCURACY OF THE NOZZLE PIEZOMETER AS DESIGNED BY F. B. SANBORN, CIVIL ENGINEER, FOR MEASURING THE PRESSURE AND DISCHARGE OF WATER FLOWING FROM FIRE NOZZLES.

| Date and Time. | Size of Nozzle. | Pressure at Base of Play Pipe. Lb. Sq. In. | Pressure Corrected. | Discharge of Nozzle. Gal. per Min. | Correction for Velocity Past Gage. | Static Pressure above Nozzle. | Pressure by Nozzle Piezometer. Lb. per Sq. In. | Pressure by Nozzle Piezometer Corrected. | Error of Nozzle Piezometer. | Per Cent. Error in Pressure. | Per Cent. Error in Gal. Flowing. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| May 1, 1906 | | | | | | | | | | | |
| 3.50 P.M. | $1\frac{1}{8}$ | 14 | 16 | 150.4 | 0.6 | 16.6 | 14.5 | 16 | — 0.6 | 3.3 | 1.9 |
| 3.55 " | $1\frac{1}{8}$ | 47 | 49 | 263.2 | 2.0 | 51.0 | 47.5 | 49 | — 2.0 | 3.9 | 2.1 |
| 3.58 " | $1\frac{1}{8}$ | 50 | 52 | 271.2 | 2.1 | 54.1 | 50.5 | 52 | — 2.1 | 3.9 | 2.1 |
| 4.20 " | $1\frac{1}{8}$ | 34.5 | 36.5 | 226.8 | 1.5 | 38.0 | 35.0 | 36.5 | — 1.5 | 3.9 | 2.1 |
| 4.30 " | $1\frac{1}{8}$ | 58 | 60 | 291 | 2.4 | 62.4 | 59.5 | 61 | — 1.4 | 2.3 | 1.2 |
| 4.32 " | $1\frac{1}{8}$ | 64 | 66 | 305.2 | 2.7 | 68.7 | 65 | 66.5 | — 2.2 | 3.2 | 1.6 |
| 4.33 " | $1\frac{1}{8}$ | 62 | 64 | 300.6 | 2.6 | 66.6 | 63.5 | 65 | — 1.6 | 2.4 | 1.3 |
| 4.35 " | $1\frac{1}{8}$ | 65 | 67 | 307.4 | 2.7 | 69.7 | 66.5 | 68 | — 1.7 | 2.5 | 1.2 |

As a result of field and laboratory tests Mr. Hadley says that he finds the per cent. of error in gallons flowing under pressure from 20 to 100 pounds would safely be said not to exceed 3 per cent.

These graduations are indistinctly shown in Fig. 2. The face of the dial gives the quantities for 10, 20, 30 lb. up to 100, and the back of the gage has a table for 5, 15, 25 lb. up to 95. Between these values interpolations can be made to the nearest pound.

In the foregoing I have referred to tests of factory pumps and public water supplies, and I now wish to emphasize the great importance of completely separating one of these supplies from the other. The public supply is sometimes given by direct pumping, but usually it consists of a gravity supply from reservoir or tank. When a factory has not the benefit of a public water supply it must erect its own tank or reservoir with capacity of 50 to 100 thousand gal.

The secondary supply in factories is usually fire pumps of large capacity connected with storage reservoirs that will last from 1.5 to 2 hr. This pump service must in no way rely upon city water to assist it; even the priming supply, which is required when the pump has to lift its water, must be independent; and the steam that drives the pump must, if necessary, be produced without the use of city water in the boilers. The importance of making the second supply entirely independent of the primary supply must never be disregarded.

At San Francisco, Baltimore and other large cities where conflagrations have quickly wiped out the whole business section and destroyed millions of dollars worth of property, the urgent need has been for a source of protection, strong and effective, that could be used independently of city water. At Baltimore numerous instances occurred where successful resistance was offered to the path of the conflagration by these independent sources of supply, and an excellent example of this sort was afforded by the fire of February 9, 1902, at Paterson, N. J. This fire started about midnight in a repair shop adjoining some wooden car sheds. A gale was blowing from the northwest — about 40 miles an hour — with the temperature 20 degrees above zero, unusually cold for that locality. Thus conditions enabled the fire to gain headway rapidly. Its sweep is shown on the map. It burned about a quarter of a mile, jumped three squares, then went on again for another quarter of a mile.

As the fire approached the mills, preparations were made to meet it with their utmost defense. Their pumps were ready; steam was up: storage reservoirs were full; men were on duty and others came to help them; lines of hose were run out 300 to 500 ft., thus to check the advance of the fire. As no city steamers or other apparatus were in this vicinity everything depended on

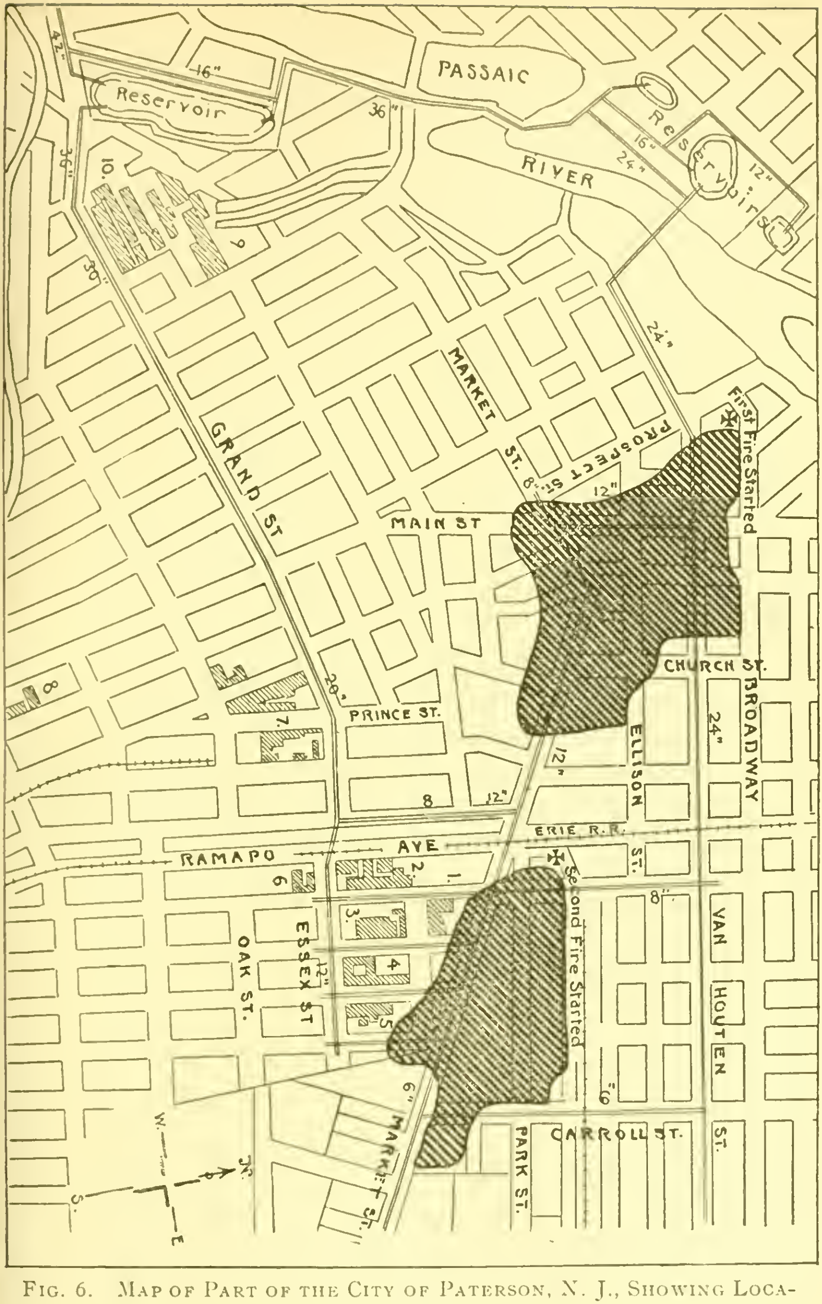


FIG. 6. MAP OF PART OF THE CITY OF PATERSON, N. J., SHOWING LOCATION OF FIRE OF FEBRUARY 9, 1902.

——— City water main feed pipes to burned district.
Heavy shading, — Burned district.
Light shading, — Mutual risks.

the mill apparatus. The success of the men's efforts is shown by the limits of the black area, which extends to within 75 ft. of one mill, 70 ft. of another and 50 ft. of a third.

I have mentioned four conditions — order, construction (coupling with that exposure), occupancy and protection — that go to make up an inspector's estimate of a factory as a fire risk. All of these four conditions deserve full consideration, but I am

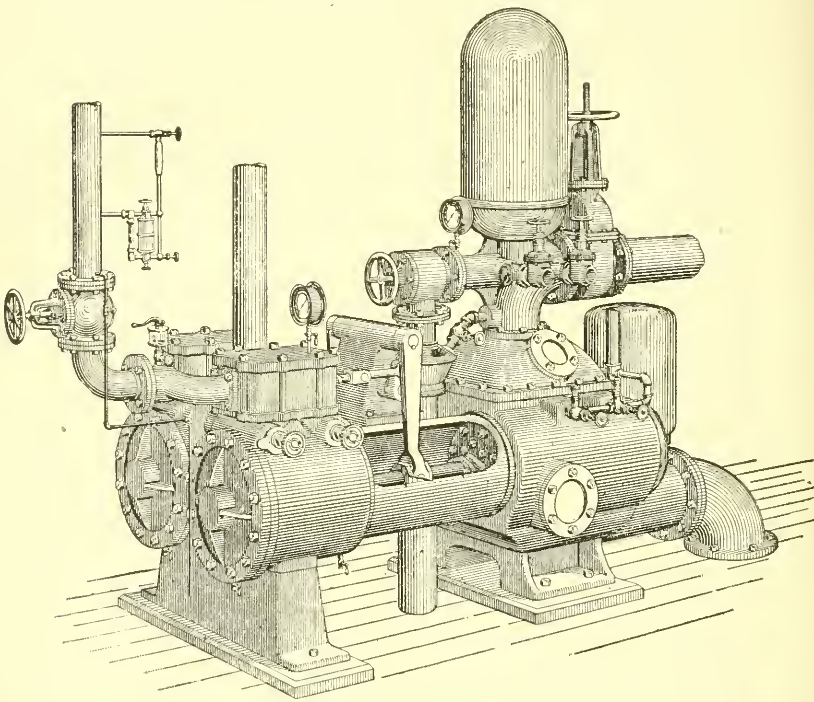

Fig. 7. An Underwriter Fire-Pump with Standard Fittings.

limiting my paper principally to two of the four, — protection and construction. Of these two I can only speak briefly and in a general way. I have already referred to some of the elements of good protection. As to construction in factories there exist two principal classes, both of which classes usually have walls of brick, stone or concrete, but are distinguished according to the construction of floors and roofs; one as joisted, the other as plank and timber.

As one observes slow-burning construction or improved fire protection becoming common in many factories the question naturally arises, Why are not means of better construction and protection with a second source of supply provided more exten-

sively in our cities, especially for business blocks, theaters and public buildings? The answer is that such changes are wrought by a very slow process. There are the owners and proprietors to be convinced; the engineers and especially the architects who often persist in having primarily " architectural effects " at the expense of good engineering; the public official and even the voter. But I earnestly believe that these great lessons — 200 million dollars consumed in this country annually: in a single conflagration, as at Baltimore, 70 million, and three times that amount at San Francisco; in terms of human lives, 586 lost in half an hour at Chicago, 960 on the *General Slocum* — will lead to the introduction of safeguards and methods of fire prevention similar to those which so many of our leading manufacturing industries have shown to be both possible and practicable.

## DISCUSSION.

Mr. S. G. Walker.* The speaker proposes, in a few words, and with pertinent facts and figures, to convey an idea of the scope of the Factory Mutual Companies in the insurance field, and their instrumentality in the development of fire protection on specific lines.

There are several groups of mutual companies who confine their operations to the insurance of manufacturing properties, but the present consideration will be confined to the senior group of New England, who, from their great advantage as to age, volume of business and financial strength, are in a position to be most discriminating in the class of risks they assume, and consequently to produce insurance at the lowest possible cost, and who are directly responsible in great degree for the development of the modern protective system.

Some seventy years ago a group of the representative manufacturers of Rhode Island who, from superiority of construction and other considerations affecting their risks, deemed themselves entitled to concessions in the matter of rates, but having been denied such consideration, joined forces to assume their own insurance, and, in 1835, a charter was granted them under the name of the Manufacturers Mutual Fire Insurance Company of Rhode Island.

The original plan of operation was to charge a rate of premium which would produce funds thought to be sufficient for

* Insurance engineer, with Manufacturers Mutual Fire Insurance Company of Providence, R. I.

the comfortable operation of the company, which was about two thirds of the then existing rate of the stock companies, and, after deducting fire losses and operating expenses, return the balance, if any, to the assured in the form of a so-termed dividend; or, in case of a deficit, an assessment was to be levied, sufficient to cover the shortage. It having proven necessary to so assess the members on several occasions, the arrangement appeared cumbersome and, in 1844, the present plan was adopted and the original rate of premium changed to roughly that charged by the stock companies, to the end that the officers were possessed of sufficient funds for prompt payment of losses and comfortable operation, and although it is a provision of law embodied in the policy that a member may be assessed to the extent of five times his premium, there has never been an assessment since that time. This fact is the more remarkable when it is considered that in the early days there was practically no protection which would be worthy of consideration as such to-day, and it was largely a matter of good fortune, and in some cases good management, as to whether the mills stood or burned.

The event, however, proved the feasibility of the scheme of insurance and the wisdom of its originators, for the system grew rapidly, new members were added and other companies formed in neighboring communities, and from this nucleus has sprung a system of 14 allied companies, carrying the insurance of over 2 000 distinct manufacturing plants and now writing 1.25 billions of dollars annually, on properties covering a territory from Halifax, Nova Scotia, to the Gulf of Mexico, and as far west as the Mississippi.

By far the greater proportion of this tremendous business is at present on risks in New England and the Middle States, and so advantageous has the system proven that probably 90 per cent. of the factories in New England, which are of such class as to be eligible for the insurance, are carried in these companies, while among the remainder there are many instances where personal considerations outweigh pecuniary advantage and cause the insurance to be placed through the stock companies' agents.

The ages of the companies are as follows:

| | |
|---|---|
| Manufacturers | 71 years |
| Rhode Island | 58 ,, |
| Boston Manufacturers | 56 ,, |
| Firemens | 52 ,, |
| State | 51 ,, |
| Worcester | 51 years |

| | |
|---|---|
| Arkwright | 46 years |
| Blackstone | 38 ,, |
| Fall River | 36 ,, |
| Mechanics | 35 ,, |
| Merchants | 33 ,, |
| Enterprise | 32 ,, |
| American | 29 ,, |
| Paper Mill | 16 ,, |

and of them, 9, including the 2 oldest, are in Providence and the remainder in Massachusetts.

The administration of the affairs of the companies is vested in the respective boards of directors, who are elected by the members, and are individually interested to a large extent in the insurance, and consequently faithful in their attendance at meetings and strict in the careful disposition of funds at their disposal.

As has been stated, the initial premium is far in excess of any sum which it is expected will be expended, and the balance, after covering expenses for operation and the payment of losses, is returned to the assured as a dividend.

On last year's business the gross premiums amounted to $9 252 000, or an average rate of 75 cents per $100, the individual rates varying from that figure according to character of respective risks.

The cost of operation was divided as follows:

| | |
|---|---|
| Salaries and office expenses | $241 140 |
| Inspection Department, including plans, appraisals, adjustments and inspections, regular and special, | 155 540 |
| Taxes | 137 190 |
| Total | $533 870 |

or about 5.75 per cent. of premiums.

The economy of operation is illustrated in no better manner than by comparing this ratio with that of expense of operation of the stock companies, which is about 40 per cent. of the annual premiums, the average premium on all classes being, if anything, larger with them.

The fire losses last year amounted to $529 530, again about 5.75 per cent. of the premiums, and the loss by accidental discharge of water from the sprinkler system, insurance against which damage is furnished by these companies without extra premium, was $38 400, or about 0.4 per cent. of the premiums, making a total expenditure of $1 101 800, or 12 per cent. of the premiums.

The moneys as they are received are invested, together with a surplus of $1 941 000, which has been accumulated through accretion in value of securities held and the wise administration of directors in the past, and this interest account, which last year amounted to $399 720, is applied towards the expenditures, leaving a net disbursement of $702 080, which is 7.6 per cent. of the gross premiums and only 6.3 per cent. of the total assets, and the companies were enabled last year to pay dividends ranging between 90 per cent. and 95 per cent. in the various instances, making the average net cost of insurance about 5.5 cents per $100.

For a term of 5 years past the dividends have ranged between 88.8 and 93.2 per cent., making the cost of insurance about 6.75 cents, and for a term of 10 years the dividends have ranged from 88.7 to 91.7 per cent., with an average net cost of insurance of about 7.5 cents per $100.

In analyzing this extremely low cost we find the economy of operation to be due to a great extent to the fact that all business is conducted from the office direct, and thus the expensive item of agents' commissions is avoided, and, at the same time, the offices are kept in intimate acquaintance with the characteristics of the risks assumed. Then there are no stockholders demanding profits, the only beneficiaries being the manufacturers themselves; furthermore, the frictionless manner of conducting the offices, coupled with the spirit of absolute fair-mindedness with which adjustments are approached, is responsible for the fact that lawsuits over settlements of loss are unknown, and expensive legal expenditures are avoided; but above all these important factors is the highly discriminating policy which demands that a risk, before being admitted, shall conform to certain standards as regards construction, occupancy, protection, exposure and management.

The standard of construction is the typical American mill construction, with brick walls and plank and timber floors and roofs wherein the combustible material is so disposed, in large masses, with smooth surfaces and a minimum of angles, as to retard combustion, and it is well named "slow-burning construction," for, in the experience of the mutual companies, there is no instance of a factory floor of this type without openings having burned completely through during the progress of a fire. A risk deviating from this standard beyond certain limits will not be acceptable for mutual insurance.

In matters of occupancy, elimination of extra hazardous

operations, isolation of the most dangerous processes, susceptibility of stock to damage by water or smoke and the possibilities of salvage when damaged, are all features which affect the eligibility of risks.

In the consideration of protection, the automatic sprinkler is unquestionably the most vital feature, as it has proved to be the most effective known appliance for the control of internal fires, for with a modern equipment in good order, there will be a sprinkler where needed and when wanted; it will work in smoke and flame and where the fireman is defied, and with a minimum of water damage in proportion to efficiency; it has in its action no dependence upon that which may be said to be only reliable for its fallibility, — human agency; it presupposes the axiom that "fire will start," and proceeds to confine fires to the locality of their incipiency, and it is hardly to be imagined that disastrous proportions will be reached in the face of such an equipment.

The mutual companies, through their officers and corps of engineers, have unquestionably been the most potent factor in the development, first of the perforated pipe systems, to which water was admitted when needed by opening valves, and which was designed to furnish inside protection, necessity for which had been demonstrated; then open-head systems, a decided advance in arrangement and distribution, though still involving extensive water damage, and finally the automatic sprinkler system in its successive stages from the first experimental equipment installed in Fall River in 1872, through its gradual adoption over the most hazardous departments in the cotton factories to the present standard of 100 per cent. sprinklered, based on the unfortunate faculty of fires for starting in unexpected places from equally unsuspected causes.

First to recognize the importance of such protection, the manufacturers, as represented by the mutual companies, have reaped rich rewards through reduction in insurance cost, although other companies refused for some years to concede the value of sprinklers by a reduction, their claim being that the liability of water damage without fire more than offset the advantage in protection, the fallacy of which stand is indicated by the fact that this liability is assumed by the mutuals without extra premium.

Even as recently as within 10 years sprinklers were not deemed essential over certain classes of occupancy, and it was an exceptional instance when a storehouse, other than for cotton or other fiber, was equipped; but from the mutual standpoint it is

preferable to buy sprinklers than to buy factories even piecemeal, and the wisdom of the present standard may be illustrated by a comparison of the dividends of 91 per cent. for the past 5 years with 87.4 per cent. for the preceding 5 years period and 70 per cent. for a period of 10 years previous to that.

Before the introduction of sprinklers the dividends fluctuated widely, in fortunate years even reaching the figures of to-day, but the average over terms of years indicates plainly not only the steadying of dividends, which is, of course, desirable, but the increase in average which improved protection has been responsible for; and since their general adoption it has been demonstrated that a heavy loss in a thoroughly protected factory may, as a probability, be considered negligible.

The cost of a sprinkler equipment is, of course, dependent upon varying conditions as to construction, the labor market and the competitive feature, and to such a degree as to render its expression in figures of doubtful guidance, but in general the cost will be between 3 and 5 cents per sq. ft. of floor area for the inside work alone, and a total of between 6 and 10 cents per sq. ft. of floor area including the provision of adequate supplies; thus the expense of a system is not great when it is considered that it is the best fireproofing device known, as it fireproofs building and contents as well.

Wholly aside from its value as a protective equipment and the consequent insurance against the interruption of production, with attendant business losses not covered by the insurance policy, the installation of a system is commonly one of the best of investments viewed from a business standpoint, through the saving effected in cost of insurance, as it is not unusual to show a saving of 90 per cent. of such cost, and the return on the amount invested will frequently net 20 per cent. and not uncommonly 50 per cent. annually.

As the mutual companies do not assume the insurance on unsprinklered risks and their net cost is usually materially under that of the stock companies, the saving would not be as great as above noted between a sprinklered and unsprinklered risk if the insurance is to be continued as before, but there should be a saving of 60 to 70 per cent., especially when conditions are such as to render the risk suitable for mutual insurance when protected and consequently subject to competition.

The feature of exposure is critical from the standpoint of the mutual companies, and their refusal to accept risks where subject to the hazard of congestion has resulted in their im-

munity from loss in any of the large conflagrations which have occurred within the period of their history. Whenever exposures are sufficient to demand serious consideration without affecting the acceptance of a risk, powerful fire pumps become an essential feature of the protection, and their value has, perhaps, never been better demonstrated than at the Paterson fire, where the pumps at the mutual risks not only saved them from destruction but, being in the path of the conflagration, were largely instrumental in preventing its further spread.

The value of careful management in the prevention of fires is beyond question, as more fires start from carelessness or preventable causes than from all others combined, and, as prevention is preferable to extinction however prompt, the general order and neatness of a plant is one of the most vital of all considerations in its standing as a fire risk, and the high standard prevailing in mutual risks as a whole in this respect is due to the efficiency of its inspection department, a corps consisting of picked men chosen for qualifications which peculiarly adapt them for efficient work, and each reporting on the risks he visits from the point of view of his previous training, but all in accordance with a scheme devised to emphasize the vital features of each case.

There are at present 14 men employed on this force, and 3 inspections of each risk are made during the year; so with the present number it takes a man somewhat over 4 years to complete the rounds, and meanwhile the officers are kept in intimate touch with conditions at the risks. By no means the least valuable feature of this system is the profit to the manufacturer from these periodical visits by men of the broadest knowledge in all matters concerning fires, their prevention and extinction, and many a heavy loss has been prevented by the timely discovery by an inspector of defects in detail or general condition of the apparatus, one such discovery often warranting the expenditure of thousands of dollars in its attainment.

This matter of the necessity for ever readiness of fire apparatus recalls to mind the case of a certain rural community, where a volunteer fire brigade with an antiquated hand pumping engine was maintained, and on the occurrence of a fire it appeared that the pump, from a long period of disuse, had developed stubbornness, and, when it was finally limbered up, the hose proved defective, all of which operated to the uninterrupted consumption of the structure on fire. This occurrence occasioned the calling of a special town meeting to take action, and one of the town fathers, to settle the matter and prevent a

recurrence of such calamities, moved that a fire committee be appointed, whose duty it should be to examine the condition of the apparatus in future 10 days before each fire, and this is in principle the result obtained by the maintenance of the mutuals' inspection department.

The secret of success of the mutual system is the disposition of the companies in every possible way to save money to the manufacturer, giving him his insurance at the lowest possible eventual cost, and to this end the policy is written on the broadest and most liberal basis possible.

An indication of the possibilities of the system in future is seen in the record for the past year of the 6 companies of which Mr. John R. Freeman is president, namely, the Manufacturers, Rhode Island, Mechanics, State, Enterprise and American, and which had a total loss on $410 000 000 insurance of only a little over $145 000, while the interest on invested assets amounted to nearly $147 000; in other words, the interest income more than covering the losses, the cost to the assured simply represented cost of operation of offices and their proportion of inspection department expenses.

Proportionate reduction in future cost hardly seems probable, as there can be no reasonable advance in the requirements for protection, although perfection in detail at the individual risk will lessen the occasional losses of unusual severity due to a combination of circumstances or of minor defects of preventable nature, which separately would be harmless.

The limit has not as yet been reached in economy of operation, for within certain limits an increase in volume of business is not attended with proportionate increase in expense of operation.

In view of the history of the companies, with a growth of 8 per cent. last year and practically doubling the volume of business in 10 years, it seems probable that the mutual system is destined to eventually cover the entire field of manufacturing activity in the United States, for the alert manufacturer will purchase his insurance, as he does other commodities, in the cheapest market.

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[NOTE. Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by November 1, 1906, for publication in a subsequent number of the JOURNAL.]

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# AZIMUTH, LATITUDE AND TIME FROM POLARIS AND A SOUTHERN STAR, WITH SURVEYOR'S TRANSIT.

BY GEORGE O. JAMES.

[Read before the Engineers' Club of St. Louis, October 18, 1905.]

## SECTION I.

OF the two ordinary methods of obtaining an approximate azimuth from Polaris and a southern star, one requires a measurement of the horizontal angle between the two stars, together with the chronometer times of bisection, while in the other this horizontal angle is made 180 degrees by setting on Polaris and then transiting the telescope through the wyes and observing the instant of passage of the southern star across the vertical thread. Comstock* gives a good account of the first method, and Seares† of the second. In this paper I have developed a form of reduction for the second method, which is at once rapid and convenient and gives a very good approximation of the azimuth of the Pole Star at the instant of bisection, the error not amounting to one tenth of a minute of arc.

The method of observing is as follows: Polaris is bisected by the vertical thread and the time noted. Then, *without changing the instrument in azimuth*, the instant of passage of a southern star across the vertical thread is noted. From the *interval* between the two bisections the azimuth of Polaris is computed, and a knowledge of the chronometer correction is, therefore, not necessary.

A watch set *roughly* to local sidereal time is necessary for finding the southern star, and the interval may be measured

* "Field Astronomy for Engineers," p. 90.

† Bulletin No. 5, Laws Observatory, University of Missouri.

on this same timepiece. A sufficiently close value of the local sidereal time is given by

$$\theta' = T_c - \Delta\lambda + Q \qquad (1)$$

Where

$T_c \equiv$ Watch time.

$\Delta\lambda \equiv$ Longitude of observer west of standard meridian.

$Q \equiv$ Sidereal time of Washington Mean Noon.

$\Delta\lambda$, if not otherwise known, may be taken with sufficient accuracy from a map, and $Q$ is taken from the *American Ephemeris and Nautical Almanac* (published each year by the Bureau of Equipment, Navy Department, Washington, D. C., price $1.00), page 400.

The southern star will transit nearly at the time

$$\theta' \doteq a, \qquad (2)$$

the difference being due

First, to the error in $\theta'$.

Second, to the telescope not being exactly in the meridian.

The first of these will depend on the error in $\Delta\lambda$, and will probably not exceed 5 min. with a good map, while the second will never be greater than 10 min. in the United States and will generally be much less.

If Polaris is west of the meridian, the southern star will transit early and should be watched for a little ahead of time.

In order that the southern star may pass across the field of the telescope, this must be set at zenith distance,

$$z = \varphi - \delta, \qquad (3)$$

where

$\varphi \equiv$ Observer's Latitude.

$\delta \equiv$ Declination of Southern Star.

The latitude need be known to the nearest minute only, and if this rough value is not known it may be obtained with sufficient accuracy by observing the altitude of Polaris and then using the table at the end of the *Ephemeris*.

The observed altitude may be used directly in this preliminary determination of a rough value of the latitude, as the refraction correction will affect the southern star to much the same extent that it does Polaris and the differential correction may be neglected.

If $\theta'$ is correct to within 10 min. of time, the local sidereal time read directly from the watch will give the latitude to within 2 minutes of arc, and much greater errors will still throw the southern star in the field of the telescope, which is all that

is desired. This rough computation of latitude may be made in a few minutes on the spot.

Suitable southern stars may be always chosen from the list "Mean Places of Standard Stars," published each year in the *Ephemeris*.

The azimuth of Polaris at the instant of bisection is computed as follows:

The hour angle of a star is

$$\tau = \theta - a,$$

where

$$\theta \equiv \text{Local Sidereal Time.}$$
$$a \equiv \text{Apparent Right Ascension of Star.}$$

Hence, for Polaris, $\tau_0 = \theta_0 - a_0$, and for the southern star, $\tau = \theta - a$.

Therefore,

$$\begin{aligned}\tau - \tau_0 &= (a - a_0) - (\theta - \theta_0)\\ &= (a - a_0) - (T_c - T_{oc}) - J'''\,(T_c - T_{oc}),\end{aligned}$$

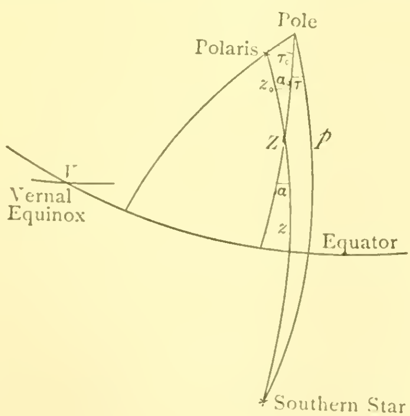
where

$T_{oc} \equiv$ Watch time of bisecting Polaris.
$T_c \equiv$ Watch time of bisecting star.
$J''' \equiv$ Correction required to reduce mean interval $T_c - T_{oc}$ to corresponding sidereal interval $\theta - \theta_0$.

This correction may be taken from Table III at the end of the *Ephemeris*, with $(T_c - T_{oc})$ as argument.

Setting $Z \equiv$ Observer's Zenith,
$\zeta \equiv$ Observer's Colatitude,
$p \equiv$ North Polar Distance of Star,
$z \equiv$ Zenith Distance of Star,
$a \equiv$ Azimuth of Star,

and letting subscripts ($_0$) refer to Polaris, we have from the figure



$$\frac{\sin\tau_o}{\sin z_o} = \frac{\sin a_o}{\sin p_o}$$

$$\frac{\sin\tau}{\sin z} = \frac{\sin a}{\sin p}$$

Whence,
$$\sin\tau = \sin a\frac{\sin z}{\sin p}.$$

Now, $a = -a_o$, and $p = 90 - \delta$.

Whence, $\sin\tau = -\sin p_o \dfrac{\sin\tau_o}{\sin z_o}\sin z \sec\delta$.

Again, $z = \varphi - \delta$ very nearly, and $z_o = 90° - (\varphi - \varepsilon_o)$, where $\varepsilon_o$ is the small correction tabulated on the last page of the *Ephemeris* with $\tau_o$ as argument.

Therefore,

$$\sin\tau = -\sin p_o \sin(\varphi - \delta)\sec\delta\sec(\varphi - \varepsilon_o)\sin\tau_o;$$

or,

$$\tau = -p_o \sin(\varphi - \delta)\sec\delta\sec(\varphi - \varepsilon_o)\sin\tau_o, \qquad (6)$$

since both $\tau$ and $p_o$ are small.

Since $\tau$ is small, an approximate value of $\tau_o$ is

$$\tau_o' = (a - a_o) - (T_c - T_{oc}) - \text{⅃}'''(T_c - T_{oc}). \qquad (7)$$

A value of $\tau$, generally correct to within 1 sec., is then given by

$$\tau' = -p_o \sin(\varphi - \delta)\sec\delta\sec(\varphi - \varepsilon_o')\sin\tau_o', \qquad (8)$$

and
$$\tau_o = \tau_o' + \tau'. \qquad (9)$$

Whence,
$$a_o = p_o \sec(\varphi - \varepsilon_o)\sin\tau_o. \qquad (10)$$

Collecting the necessary formulæ:

$$\left\{\begin{array}{lll} \tau_o' & = (a - a_o) - (T_c - T_{oc}) - \text{⅃}'''(T_c - T_{oc}). & [1] \\ \tau' & = -p_o \sin(\varphi - \delta)\sec\delta\sec(\varphi - \varepsilon_o')\sin\tau_o'. & [2] \\ \tau_o & = \tau_o' + \tau'. & [3] \\ a_o & = p_o \sec(\varphi - \varepsilon_o)\sin\tau_o. & [4] \end{array}\right.$$

The $a$ and $\delta$ used in the computation should be taken from "Apparent Places of Standard Stars" in the *Ephemeris.*

The following example illustrates the computation:

*Station:* W. U. *Date:* May 7, 1905.

| | $T_c$ | | |
|---|---|---|---|
| Polaris . . . . . . . . . . . | $10^h$ | $15^m$ | $17^s$ |
| $a$ Virginis . . . . . . . . . | $10^h$ | $20^m$ | $33^s.5$ |

*Computation.*

$$a = 13^h\ 20^m\ 13^s$$
$$a_o = 1\ \ 24\ \ 17$$
$$a - a_o = 11\ \ 55\ \ 56$$
$$-(T_c - T_{oc}) = -5\ \ 16.5$$
$$-\Delta'''(T_c - T_{oc}) = -0.9$$

$$\tau_o' = 11^h\ 50^m\ 39^s$$
$$= 177^\circ\ 39'.8$$

| | | | |
|---|---|---|---|
| $p_o =$ | $72'.2$ | $\log(-p_o) =$ | $1.8585n$ |
| $\phi =$ | $38^\circ\ 39'$ | $\log \sin(\varphi - \delta) =$ | $9.8799$ |
| $\delta =$ | $-10\ \ 40$ | $\log \sec \delta =$ | $.0076$ |
| $\varepsilon'_o =$ | $1\ \ 12$ | $\log \sec(\varphi - \varepsilon'_o) =$ | $.1002$ |
| $\varphi - \delta =$ | $49\ \ 19$ | $\log \sin \tau'_o =$ | $8.6104$ |
| $\varphi - \varepsilon'_o =$ | $37\ \ 27$ | | |
| | | $\log \tau' =$ | $.4566n$ |

$$\tau' = -2'.9$$
$$\tau_o = 177^\circ 36'.9$$

$$\log p_o = 1.8585$$
$$\log \sec(\varphi - \varepsilon_o) = .1002$$
$$\log \sin \tau_o = 8.6192$$

$$\log a_o = .5779$$
$$a_o = 3'.8$$

If the azimuth of a mark is desired, several readings on mark and Polaris should be taken, and combined with an observation on Polaris and a southern star as follows:

Let $M$ ≡ Mean of circle readings on Mark.
$M_o$ ≡ Mean of circle readings on Polaris.
$N$ ≡ Circle reading on North.
$T_{om}$ ≡ Mean of watch times of bisecting Polaris.
$\tau_{om}$ ≡ Hour angle of Polaris at $T_{om}$.
$a_{om}$ ≡ Azimuth of Polaris at $T_{om}$.
$T_{oc}$ ≡ Time of transit of Polaris.
$T_c$ ≡ Time of transit of Southern Star.
$\tau_o$ ≡ Hour angle of Polaris at transit.

Then

$$\left\{\begin{aligned} \tau_{om} &= \tau_o + (T_{om} - T_{oc}) + \Delta'''(T_{om} - T_{oc}). && [1]\\ a_{om} &= p_o \sec(\varphi - \varepsilon_o) \sin \tau_{om}. && [2]\\ N &= a_{om} + M_o. && [3] \end{aligned}\right.$$

In the following example four settings on Polaris were made, two with circle east and two west, and at the fourth bisection the transit of the time star $\delta$ Sculptoris was observed.

$$
\begin{array}{rcl}
M_o & = & 179^\circ\ 2'.4 \\
T_{om} & = & 23^h\ 25^m\ 14^s.5 \\
T_{oc} & = & 23\ \ 35\ \ 43 \\
T_c & = & 23\ \ 38\ \ \ 3.5 \\
a & = & 23\ \ 43\ \ 58 \\
a_o & = & 1\ \ 25\ \ 57 \\
a - a_o & = & 22\ \ 18\ \ \ 1 \\
-(T_c - T_{oc}) & = & -2\ \ 20.5 \\
-\lrcorner'''\,(T_c - T_{oc}) & = & -.4 \\
\hline
\tau_o' & = & 22^h\ 15^m\ 40^s \\
 & = & -26^\circ\ 5' \\
\hline
\log(-p_o) & = & 1.8573n \\
\log\sin(\varphi - \delta) & = & 9.9659 \\
\log\sec\delta & = & .0567 \\
\log\sec(\varphi - \varepsilon_o') & = & .1160 \\
\log\sin\tau_o' & = & 9.6431n \\
\hline
\tau' & = & 43'.6 \\
\tau_o & = & -25^\circ\ 21'.4 \\
T_{om} - T_{oc} & = & -2\ \ \ 37.1 \\
\lrcorner'''\,(T_{om} - T_{oc}) & = & 0.4 \\
\tau_{om} & = & -27^\circ\ 59' \\
\log p_o & = & 1.8573 \\
\log\sec(\varphi - \varepsilon_o) & = & .1160 \\
\log\sin\tau_{om} & = & 9.6714n \\
\hline
\log a_{om} & = & 1.6447n \\
a_{om} & = & -44'.1 \\
M_o & = & 179^\circ\ \ 2'.4 \\
N & = & 178^\circ\ \ 18'.3
\end{array}
$$

This is exactly the value obtained by more accurate and extended computation. The value of $N$ combined with that of $M$ gives the azimuth of the mark.

## Section 2.

An approximate determination of the observer's latitude may be made from an observation on Polaris and a southern star combined with a series of measurements of the altitude of Polaris. The mean of these corrected for refraction gives the altitude of Polaris at the mean of the observed times. Comstock's formula for refraction is

$$R = [2.6898] \frac{\cot h'_m}{456+F}$$

where $R \equiv$ Refraction in minutes of arc.
$[2.6898] \equiv$ Logarithm of numerical factor.
$h'_m \equiv$ Mean of observed altitudes.
$F \equiv$ Temperature in degrees Fahrenheit.

The hour angle $\tau_{om}$, of Polaris at the mean instant, $T_{om}$ having been computed as above, the latitude is given by

$$\varphi = h_{om} - p_o \cos \tau_{om} + [\bar{4}.1627]\, p_o^2 \sin^2 \tau_{om} \tan h_{om}$$

where all terms in the right-hand member except the first are in minutes of arc.

The following example will illustrate the method:

The mean of six altitudes of Polaris — three circle east and three west — gave

$$h'_{om} = 37^\circ\ 45'.45$$
$$T_{om} = 8^h\ 47^m\ 9^s.5,$$

while the times of transit of Polaris and the southern star $\theta$ Virginis were

$$T_{oc} = 9^h\ 54^m\ 39^s.5$$
$$T_c = 10\quad 5\quad 15$$

From the *Ephemeris* for the date May 7, 1905:

$$\alpha = 13^h\ 5^m\ 3^s.5 \qquad \delta = -5^\circ\ 2'$$
$$\alpha_o = 1\ \ 24\ \ 16.5 \qquad \delta_o = 88\ \ 47.85$$
$$p_o = 72.15$$

$$\alpha - \alpha_o = 11^h\ \ 40^m\ 47^s$$
$$-(T_c - T_{oc}) = -10\ \ 35.5$$
$$-\Delta'''(T_c - T_{oc}) = -1.7$$

$$\tau_o' = 11^h\ \ 30^m\ \ 10^s$$
$$= 173^\circ\ 10'$$

| | |
|---|---|
| $\varphi = 38^\circ\ 50'$ (rough) | $\log(-p_o) = 1.8584n$ |
| $\varepsilon_o' = 1\ \ 12$ | $\log\sin(\varphi - \delta) = 9.8407$ |
| $\varphi - \delta = 43\ \ 52$ | $\log\sec\delta = .0017$ |
| | $\log\sec(\varphi - \varepsilon_o') = .1013$ |
| $\varphi - \varepsilon_o' = 37\ \ 38$ | $\log\sin\tau_o' = 9.0755$ |
| | $\log\tau' = .8776n$ |

$$\tau' = -7'.544 = -1^m\ \ 53^s$$
$$\tau_o = 11^h\ 28^m\ \ 17^s.$$

$$T_{om} - T_{oc} = -1^h\ 7^m\ 30^s$$
$$\Delta'''(T_{om} - T_{oc}) = \quad -11$$
$$\tau_{om} = 10^h\ 20^m\ 36^s$$
$$= 155^\circ\ 9'$$
$$h'_{om} = 37^\circ\ 45'.45$$
$$R = 1.225$$
$$\text{1st term} = h_{om} = 37^\circ\ 44'.22$$

$$\bar{4}.1627$$

| | |
|---|---|
| $\log p_o = 1.8582$ | $2 \log p_o = 3.7164$ |
| $\log \cos \tau_{om} = 9.9578\ n$ | $2 \log \sin \tau_{om} = 9.2470$ |
| $\text{sum} = 1.8160\ n$ | $\log \tan h_{om} = 9.8887$ |
| $\text{2d term} = -65'.47$ | $\text{sum} = \bar{1}.0148$ |
| | $\text{3d term} = 0'.104$ |

$$\varphi = 37^\circ\ 44'.22 + 65'.47 + 0'.104$$
$$= 38^\circ\ 49'.8$$

## Section 3.

If the observer's longitude is known to within 2 min. of time, a good approximation of the chronometer correction on local mean time may be obtained from a single setting on Polaris and a southern star with very little additional computation.

The necessary equations are:

$$\tau_o' = a - a_o - (T_c - T_{oc}) - \Delta'''(T_c - T_{oc}), \qquad [1]$$
$$\tau' = -p_o'' \sin(\varphi - \delta) \sec \delta \sec(\varphi - \varepsilon_o') \sin \tau_o', \qquad [2]$$
$$\tau_o = \tau_o' + \tau', \qquad [3]$$
$$\tau = -p_o'' \sin(\varphi - \delta) \sec \delta \sec(\varphi - \varepsilon_o) \sin \tau_o, \qquad [4]$$
$$\theta = \tau + a, \qquad [5]$$
$$T = (\theta - \Theta) - \Delta''(\theta - \Theta) - \Delta''\lambda, \qquad [6]$$
$$\Delta T_c = T - T_c, \qquad [7]$$

where $\Theta \equiv$ Sidereal time of Greenwich Mean Noon.

$\Delta'' \equiv$ Correction required to reduce a sidereal interval to the corresponding mean interval.

$\lambda \equiv$ Observer's longitude west of Greenwich.

The correction $\Delta''$ may be taken from Table II at the end of the *Ephemeris* with sidereal interval as argument.

*Station:* W. U. *Date:* May 7, 1905.

| Observer. | Beals. | | | Traber. | | |
|---|---|---|---|---|---|---|
| Southern Star. | α Virginis. | | | π Hydrae. | | |
| $T_{oc}$ | $10^h$ | $15^m$ | $17^s$ | $10^h$ | $53^m$ | $45^s$ |
| $T_c$ | 10 | 20 | 33.5 | 11 | 2 | 11.5 |

*Reduction.*

$\varphi = 38^\circ\ 39'$ $\lambda = 6^h\ 1^m$

| $p_0 = 4329''$ | $\alpha$ Virginis. | | | $\pi$ Hydrae. | | |
|---|---|---|---|---|---|---|
| $\alpha$ | $13^h$ | $20^m$ | $13^s.0$ | $14^h$ | $0^m$ | $59^s.8$ |
| $\alpha_0$ | 1 | 24 | 17 | 1 | 24 | 17 |
| $\alpha - \alpha_0$ | 11 | 55 | 56 | 12 | 36 | 43 |
| $-(T_c - T_{oc})$ | | $-5$ | 16.5 | | $-8$ | 26.5 |
| $-\Delta'''(T_c - T_{oc})$ | | | $-.9$ | | | $-1.5$ |
| $\tau_0'$ | $11^h$ | $50^m$ | $39^s$ | $12^h$ | $28^m$ | $15^s$ |
| | $177^\circ$ | $39'.8$ | | $187^\circ$ | $3'.8$ | |
| $\varphi$ | $38^h$ | $39^m$ | | $38^h$ | $39^m$ | |
| $\delta$ | $-10$ | 40.1 | | $-26$ | 13.6 | |
| $\epsilon_0'$ | 1 | 12.1 | | 1 | 11.7 | |
| $\varphi - \delta$ | 49 | 19.1 | | 64 | 52.6 | |
| $\varphi - \epsilon_0'$ | 37 | 26.9 | | 37 | 27.3 | |
| log $(-p_0'')$ | $3.63639n$ | | | $3.63639n$ | | |
| sin $(\varphi - \delta)$ | 9.87986 | | | 9.95684 | | |
| sec $\delta$ | .00757 | | | .04718 | | |
| sec $(\varphi - \epsilon_0')$ | .10023 | | | .10027 | | |
| sin $\tau_0'$ | 8.61035 | | | $9.08979n$ | | |
| log $\tau'$ | $2.23440n$ | | | 2.83047 | | |
| $\tau'$ | $-171''.6 = -2'.9 = -11^s.4$ | | | $676''.8 = 11'.3 = 45^s.1$ | | |
| $\tau_0$ | $11^h$ | $50^m$ | $27^s.6$ | $12^h$ | $29^m$ | $00^s.1$ |
| | $177^\circ$ | $36'.9$ | | $187^\circ$ | $15'.1$ | |
| $\epsilon_0$ | 1 | 12.1 | | 1 | 11.6 | |
| $\varphi - \epsilon_0$ | 37 | 26.9 | | 37 | 27.4 | |
| log $(-p_0'')$ | $3.63639n$ | | | $3.63639n$ | | |
| log sin $(\varphi - \delta)$ | 9.87986 | | | 9.95684 | | |
| log sec $\delta$ | .00757 | | | .04718 | | |
| log sec $(\varphi - \epsilon_0)$ | .10023 | | | .10028 | | |
| log sin $\tau_0$ | 8.61924 | | | $9.10206n$ | | |
| log $\tau$ | $2.24329n$ | | | 2.84275 | | |
| $\tau$ | $-175''.1 =$ | | $-11^s.7$ | $696''.2 =$ | | $46^s.4$ |
| $\alpha$ | $13^h$ | $20^m$ | $13^s$ | $14^h$ | $0^m$ | $59^s.8$ |
| $\theta$ | 13 | 20 | 1.3 | 14 | 1 | 46.2 |
| $\Theta$ | 2 | 58 | 37.94 | 2 | 58 | 37.94 |
| $\theta - \Theta$ | $10^h$ | $21^m$ | $23^s.36$ | $11^h$ | $3^m$ | $8^s.26$ |
| $-\Delta''(\theta - \Theta)$ | | $-1$ | 41.80 | | $-1$ | 48.64 |
| $-\Delta''\ \lambda$ | | | $-59.14$ | | | $-59.14$ |
| $T$ | $10^h$ | $18^m$ | $42.42^s$ | $11^h$ | $0^m$ | $20^s.48$ |
| $T_c$ | 10 | 20 | 33.5 | 11 | 2 | 11.5 |
| $\Delta T_c$ | | $-1$ | 51.1 | | $-1$ | 51.0 |

The collimation error in the transit may be eliminated by combining two observations on two southern stars of nearly equal declinations, one observed with circle east and the other with circle west.

[NOTE. Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by November 15, 1906, for publication in a subsequent number of the JOURNAL.]

# THE RECONSTRUCTION OF THE OLIVE STREET TRACK.

By Richard McCulloch, Member of the Engineers' Club of St. Louis.

[Read before the Club, September 19, 1906.]

The first street railway track laid in the city of St. Louis was that laid on Olive Street from Fourth Street to Fourteenth Street. The original rail was a flat strap rail, and the road was opened for traffic as a horse-car line on the Fourth of July, 1859. The initial trip was the occasion of great public rejoicing, as it was considered that a great step in the city's progress had been made. As the city grew, Olive Street developed into an important retail business street, and the Olive Street line became the artery uniting the business district with the most important residence district of the city.

In 1887 the Olive Street line was converted into a cable line, a double cable track being built from Fourth Street to Boyle Avenue, a distance of 3.5 miles. In this construction a girder rail, 4½ in. in height, weighing 63 lb. per yard, was laid on cast-iron yokes weighing 300 lb. each, set in concrete 4 ft. apart. These yokes were 48 in. in depth and inclosed a conduit for the

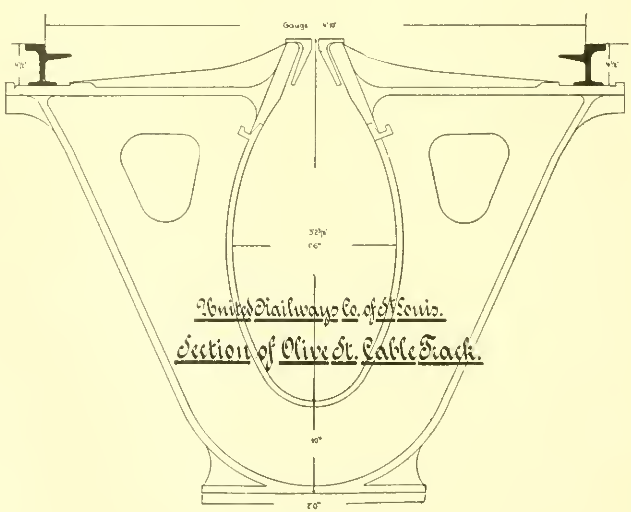



Fig. 1.

cable 38 in. in depth. A cross-section of this construction is shown in Fig. 1. This cable road was one of the first built east of San Francisco. All of the St. Louis cable roads adopted the 38-in. conduit. In cable roads afterwards built in New York City the conduit depth was reduced to 24 in., making a much stronger roadbed, and greatly reducing the cost of construction.

The original rail having worn out, in 1898 the rail of the cable road was renewed. In the original construction the rail had been bolted directly to the yokes by means of hook bolts without the use of chairs, and it was, therefore, impossible to increase the height of the rail on the yokes. In the 1898 reconstruction an extra heavy section of $4\frac{1}{2}$-in. rail weighing 67 lb. per yard was used. In 1901 the road was converted into an electric road, electric cars being operated over the cable roadbed without change.

This rail, however, was entirely too light for service under heavy electric cars. In 1903, the year before the World's Fair, about one half of the track was relaid, the portions selected for relaying being the downhill parts of the track where the speed of the cars was greater. In the 1903 reconstruction it was not considered advisable to take the cars off the street during the reconstruction, and the very novel method of laying the track with a 9-in. rail for the outside rail and a $6\frac{5}{8}$-in. rail for the inside rail was adopted. The 9-in. rail was laid 7 in. outside of the

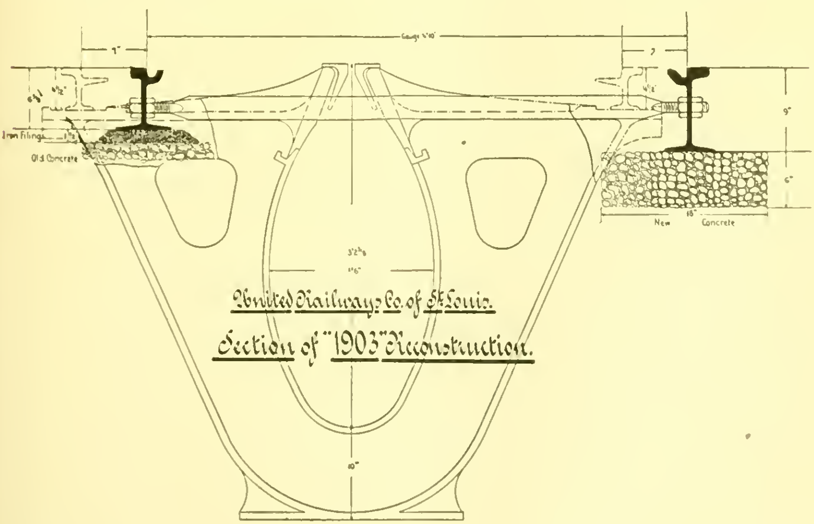


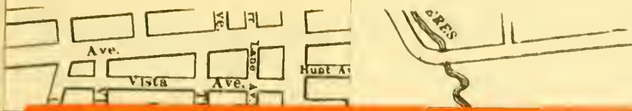

FIG. 2.

gage line of the track on a concrete stringer 18 in. wide and 6 in. deep. The $6\frac{5}{8}$-in. rail was laid on the old concrete of the cable road and tamped to surface with a mixture of iron borings and salt about $1\frac{1}{2}$ in. deep. The concrete under the 9-in. rail was given about 5 days to set. The bed of iron borings under the $6\frac{5}{8}$-in. rail was given only a few hours to set, as the rail was laid at night and cars run over it the next day. The two rails were tied together by steel tie rods spaced 6 ft. apart. Fig. 2 shows this construction. The reasons for this unusual construction were to enable the track to be relaid without interfering with car service on the street, and to avoid the expense of excavating the concrete roadbed of the cable road. The results obtained, however, were not at all satisfactory. The shallow concrete stringer under the 9-in. rail broke in a number of places and left this rail without support. The iron borings under the $6\frac{5}{8}$-in. rail did not set to form a hard mass, and this rail, being left loose, deflected up and down as cars went over it, working the paving loose and emitting a horrible grinding and chattering noise which gave rise to constant complaint. The two rails were not sufficiently tied together, and frequent wide gage was the result.

In the spring of 1906, when it was necessary to relay the old cable track on account of the rail being worn out, that portion of the track reconstructed in 1903 was in such bad condition that it was considered best to relay both of the tracks and put the street into first-class shape.

In order to understand the need for speed in the construction, it should be stated that the Olive Street line is the one having the heaviest traffic in the United Railways system. During the middle of the day the cars are 1.5 minutes apart, and night and morning during the hours of heaviest travel, the headway between cars is reduced to 50 seconds. Olive Street throughout its entire length is a narrow street, only 36 ft. wide between curbs, and lined with retail stores. As a concrete construction for the track was decided upon, it was necessary to remove the cars from each track during its construction. The street being entirely too narrow for a third temporary track, it was necessary to route the cars over another parallel line. Hence, any delay in the progress of the construction would mean annoyance to the residents and shopkeepers along the street, inconvenience to the regular patrons of the line and loss of traffic to the railroad.

After a number of plans had been considered, it was decided to perform the work in two sections, building both tracks between




*Foldout*

*Here*

Fourteenth Street and Boyle Avenue (29 118 ft. of track equal to 5.51 miles) early in the spring, and that portion between Sixth Street and Fourteenth Street (3 670 ft. of track equal to 0.69 miles) during the middle of the summer. The work between Sixth Street and Fourteenth Street was postponed until the summer at the request of the merchants on lower Olive Street, who did not like to see their spring trade interfered with.

It was decided to use the single track on Olive Street not under construction for west-bound cars, sending east-bound Wellston cars down Washington Avenue and across Fourteenth Street to Olive Street, and the east-bound McPherson and Maryland cars over Boyle Avenue to Laclede Avenue, down Laclede Avenue and across Thirteenth Street to Olive Street. Fig. 3 shows this routing. In order to make these changes in routing, a temporary track was laid in Boyle Avenue from Maryland Avenue to Laclede Avenue, a distance of about 1 500 ft. This temporary track was laid with 75 lb. T-rail spiked to wooden ties, the ties being placed on top of the brick pavement of the street. In passing, it is interesting to note that when this temporary track was removed after cars had been running over it for six weeks, absolutely no damage whatever had been done to the brick pavement.

For the new track there was adopted a girder Trilby rail, 9 in. high, laid on cypress ties spaced 2 ft. between centers. Brace tie plates and Goldie claw tie plates were used on alternate

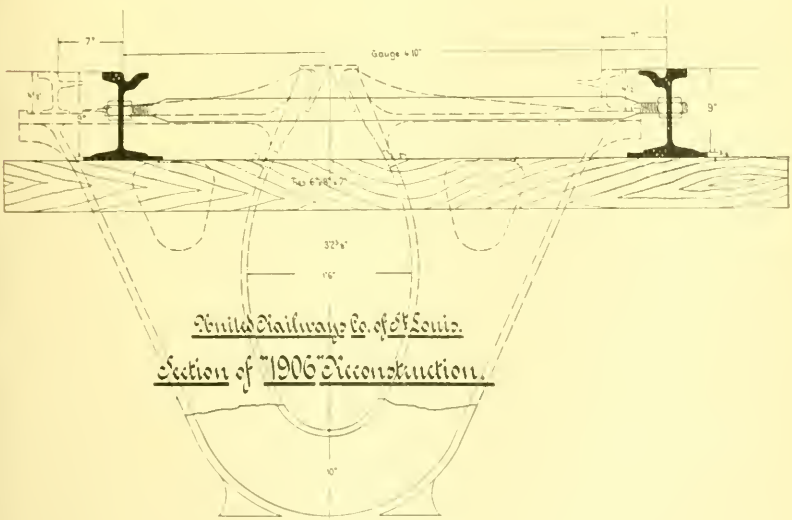



Fig. 4.

ties. Tie rods, 2 in. by $\frac{3}{8}$ in. in section, were spaced 6 ft. apart. Six inches of Portland cement concrete was placed beneath the ties, and the concrete was carried up high enough on the rail to support the style of paving adopted, making a thickness of 14 in. of concrete in the case of granite paving and 18 in. for asphalt paving. In either case the wooden tie was entirely embedded in the concrete. This construction is shown in Fig. 4. For the first portion of the reconstruction the work was divided into three sections: Section No. 1, Fourteenth Street to Jefferson Avenue; section No. 2, Jefferson Avenue to Grand Avenue; section No. 3, Grand Avenue to Boyle Avenue. Each of these sections is about a mile of double track. Three separate foremen with independent gangs were put in charge, each foreman in charge of a section. Work was carried on day and night.

### Excavation.

In order to build the track, it was necessary to make an excavation 21 in. in depth in a concrete which had been setting for 18 years, and which experience in whatever excavations had been made had shown to be extremely hard. If it had been necessary to pick out six miles of this concrete by hand the cost would have been excessive, and, disregarding the cost, the time involved and the number of men required would have been prohibitory of that method.

### Drilling and Blasting.

The method adopted for excavating the concrete was by blasting with small charges of dynamite, the object being to make these charges strong enough to shatter the concrete so that it could be taken out in large pieces, but not heavy enough to do other damage. Holes were drilled 7 to 8 in. deep in the concrete, four holes between each pair of yokes. The hole was so located that the bottom of the hole was a little below the center of gravity of the section of concrete to be removed. The location of the holes is shown in Fig. 5. For drilling the holes there were used No. 2 Little Jap drills made by the Ingersoll Rand Company, operated by compressed air at 90 lb. pressure. This tool drills a 1.25-in. hole. A dry hole is drilled, the exhaust air from the hollow drill steel blowing the dust from the hole and keeping it clean. Common labor was used to run the drills and very little mechanical trouble was experienced. Three cars were fitted up, one for each gang, each car being equipped with

a motor-driven air compressor, water for cooling the compressors being obtained from the fire plugs along the route. The air compressors were taken temporarily from those in use in the repair shops, no special machines being bought for the purpose.

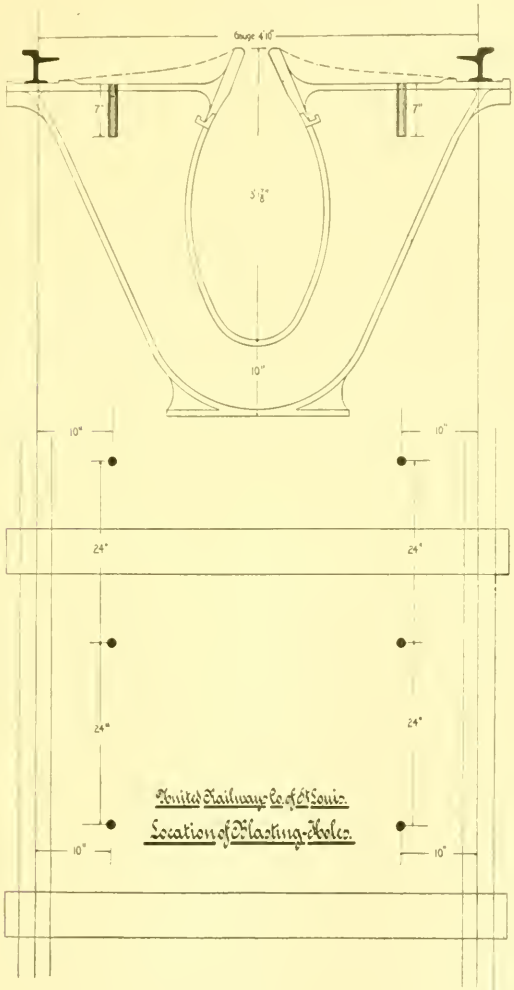



FIG. 5.

Current for operating the air compressor motors was taken from the trolley wire over the tracks. The car was moved along as the holes were drilled, air being conveyed from the car to the drills through a flexible hose. Two drills were operated nor-

mally from each car. One of the air compressors was exceptionally large and at times operated four drills. The total number of holes drilled in the reconstruction of the track was 31 000. The total feet of hole drilled was 20 700 feet. The following figures give the average performance of the best one of the drilling outfits, which operated from two to three drills:

| | |
|---|---|
| Depth of hole | 8 in. |
| Number of holes per hour per drill | 30 |
| Feet of hole drilled per hour per drill | 20.3 |
| Labor cost per foot of hole drilled | $0.027 |
| Labor cost of drilling per cu. yd. blasted | $0.085 |
| Drilling cost per lineal foot of track | $0.017 |
| Drilling cost per mile of track | $89.76 |

In these figures there is no charge for electric power or for depreciation of machinery.

For blasting, a 0.1 lb. charge of 40 per cent. dynamite was used in each hole. A fulminating cap was used to explode the charge, and twelve holes were shot at one time by an electric firing machine. The dynamite was furnished from the factory in 0.1 lb. packages, and all the preparation necessary on the work was to insert the fulminating cap in the dynamite, tamp the charge into the hole and connect the wires to the firing machine. In order to prevent any damage being done by flying rocks at the time of the explosion, each blasting gang was supplied with a cover car, which was merely a flat car with a heavy bottom and side boards. When a charge was to be fired, this car was run over the twelve holes and the side boards let down, so that the charge was entirely covered. This work was remarkably free from accidents. There were no personal accident claims whatever, and the total amount paid out for property damages for the whole six miles of construction was $685. Most of this was for glass broken by the shock of explosion. There was no glass broken by flying particles. The men doing this work, few of whom had ever done blasting before, soon became very expeditious in handling the dynamite, and the work advanced rapidly. The report made by the firing of the twelve holes was no greater than that made by the giant fire-crackers so common in the streets on the Fourth of July.

For the drilling and blasting the old rail had been left in place to carry the air compressor car and the cover car. After the blasting, this rail was removed and the concrete excavated to the required depth. In most cases the cable yokes had been


FIG. 6. PNEUMATIC DRILLS AND COMPRESSOR CAR.

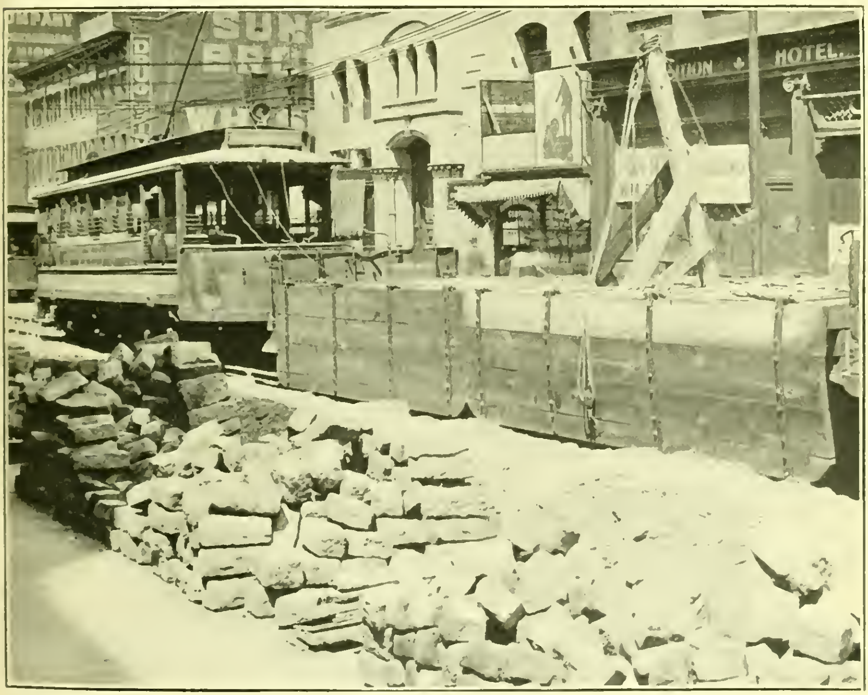



FIG. 7. COVER CAR USED FOR BLASTING IN OLIVE STREET.

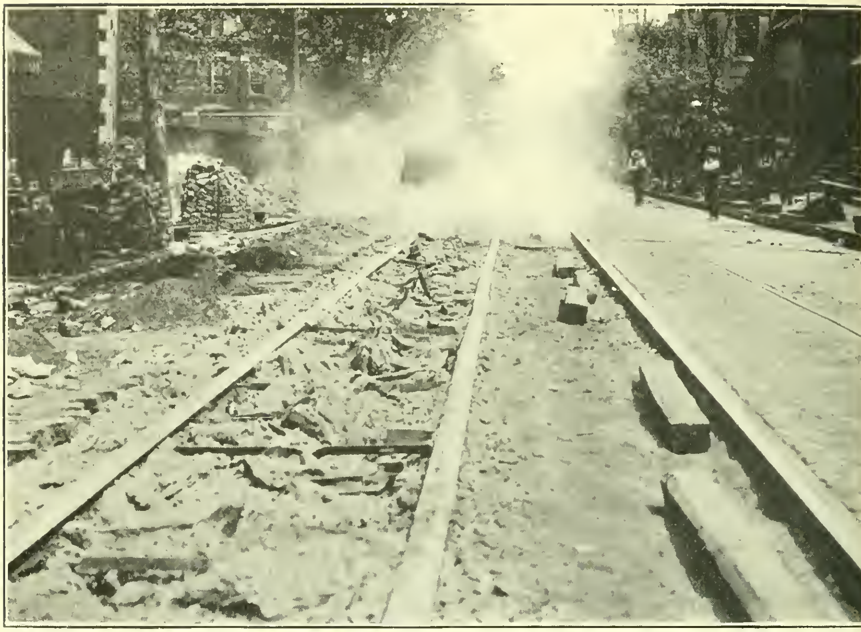


Fig. 8. Blasting Concrete in Olive Street.

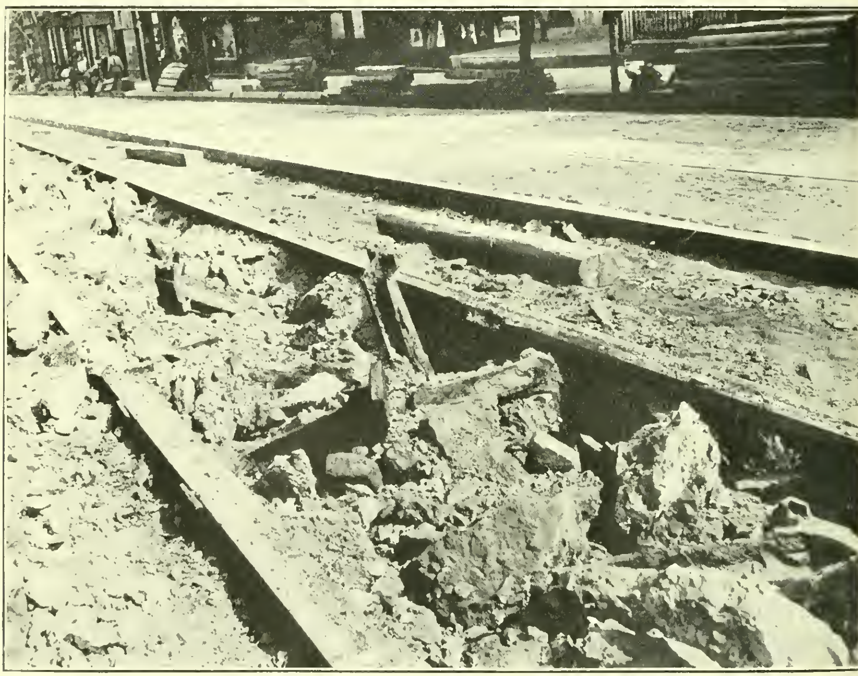


Fig. 9. Effect of Blasting on Concrete Cable Conduit.

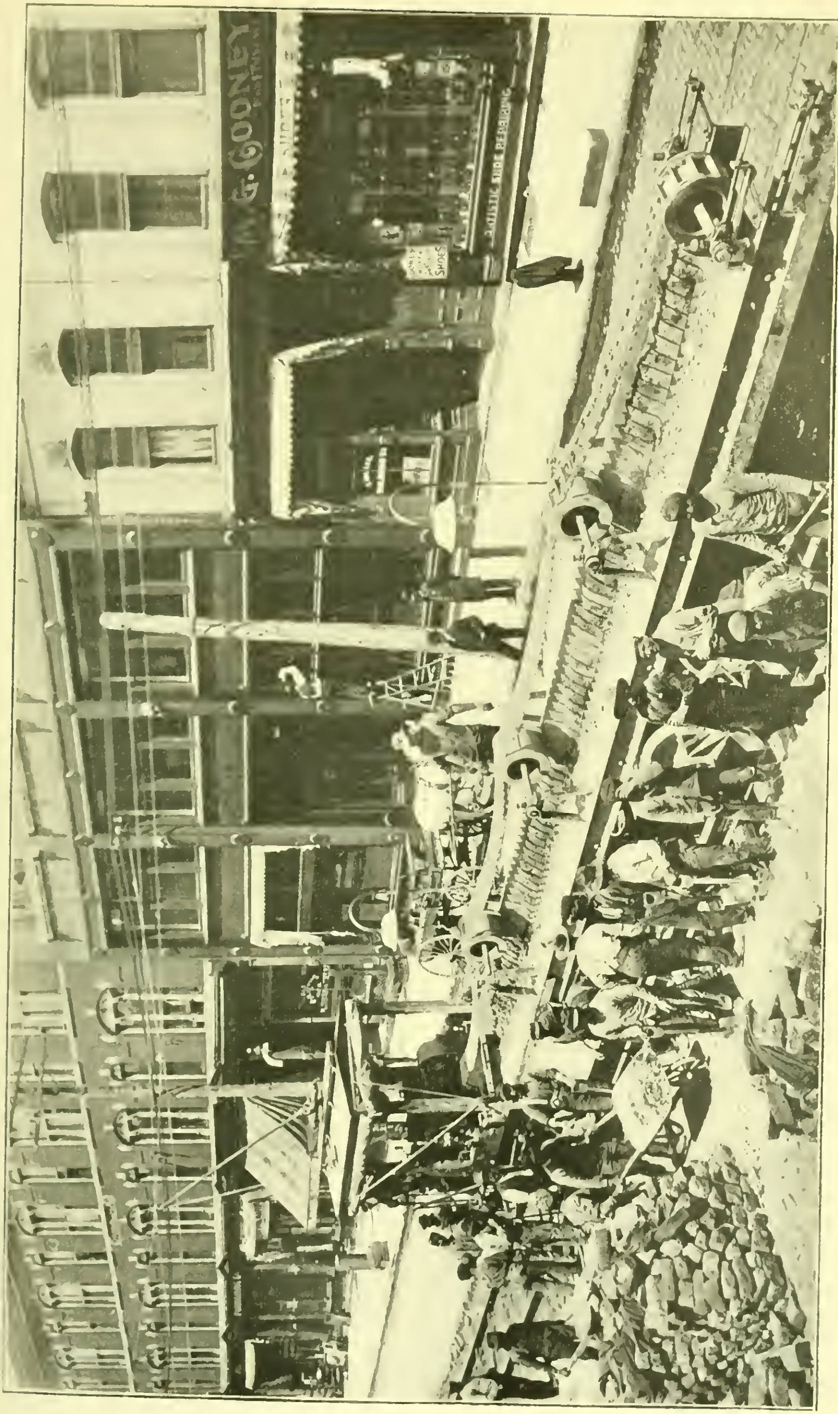


FIG. 11. HIGH CONCRETE MIXING MACHINE.

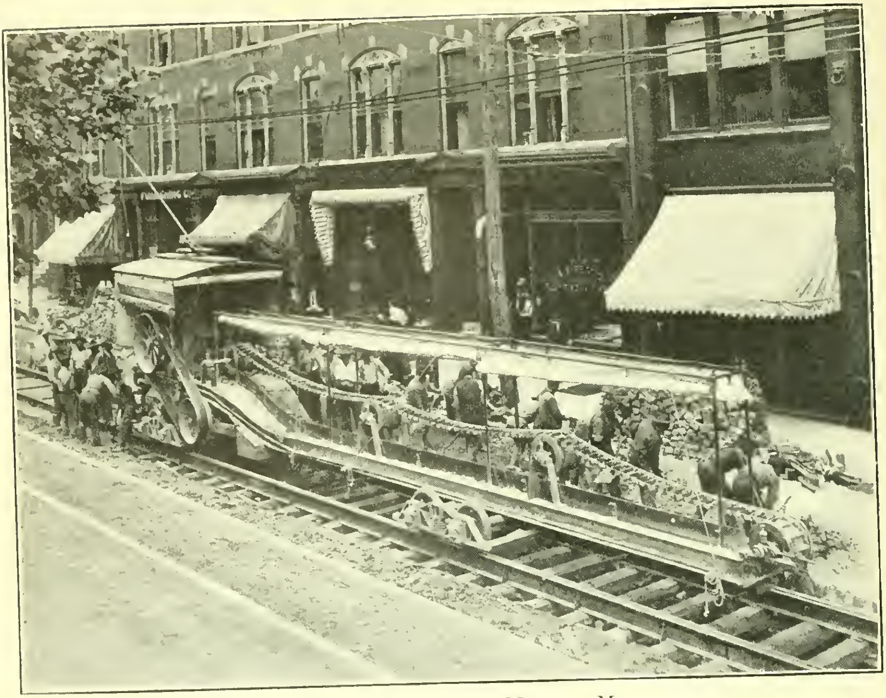


Fig. 12. Low Concrete Mixing Machine.

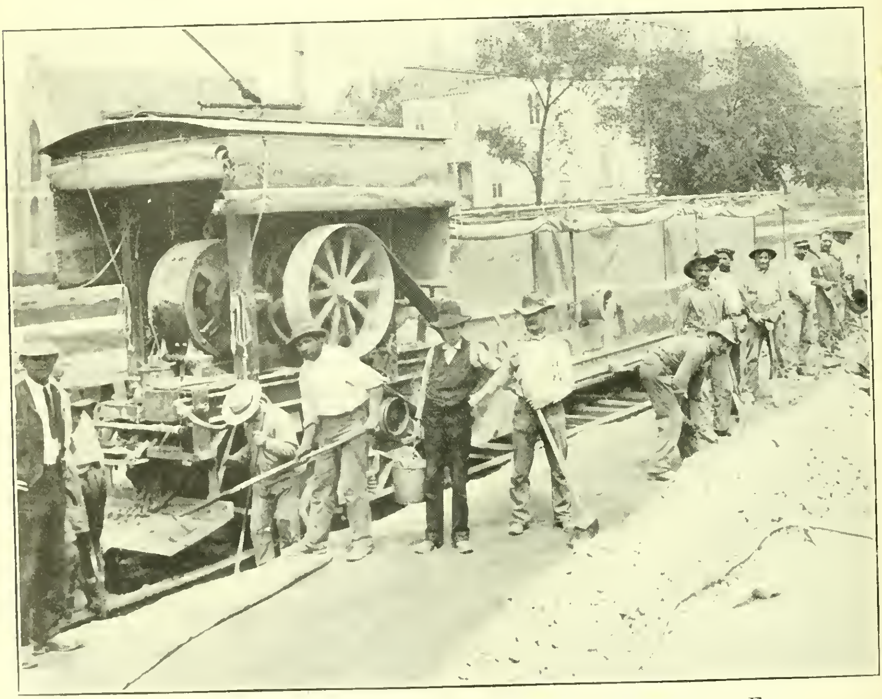


Fig. 13. Low Concrete Mixing Machine. Discharging End.


FIG. 14. TRACK LINED AND SURFACED, READY FOR CONCRETING.

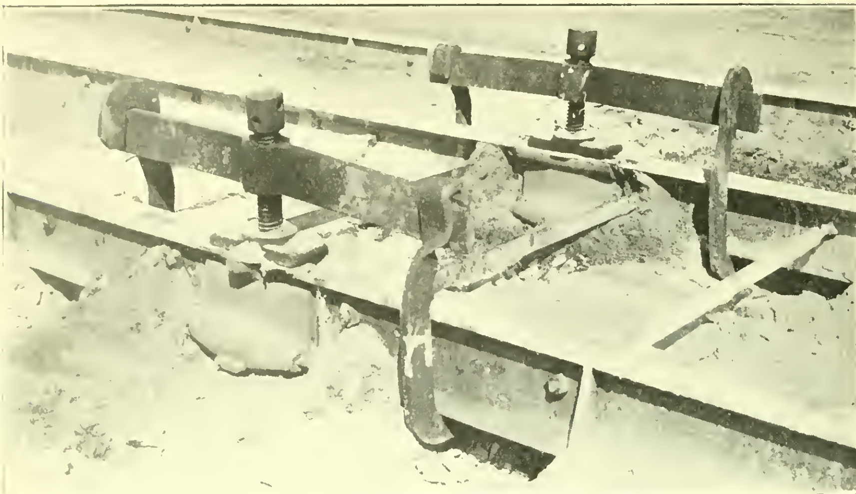


Fig. 15. Cast Weld Joint, before Removing Clamps.

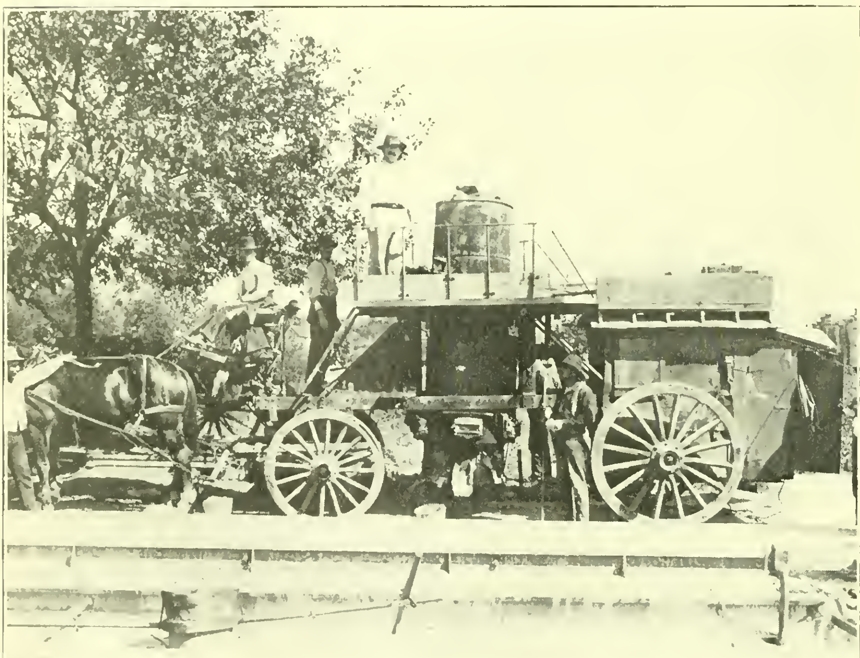


Fig. 16. Portable Cupola for Cast Welding.

broken by the force of the blast. Where these yokes had not been broken, they were knocked out by blows from pieces of rail. The efficacy of the blasting depended largely upon the proper location of the hole. Where the holes had been drilled close to the middle of the concrete block, so that the dynamite charge was exploded a little below the center of gravity of the section, the concrete was well shattered and could be picked out in large pieces. Where the hole had been located too close to either side of the concrete block, however, the charge would blow out at one side and a large mass of solid concrete would be left intact on the other side. The total estimated quantity of concrete blasted was 6 558 cu. yd., or 0.2 cu. yd. of concrete per lineal foot of track. The cost of the dynamite delivered in 0.1 lb. packages was 13 cents per pound. The exploders cost $0.0255 each.

The following statistics represent the average work of the three gangs working on the west-bound track between Fourteenth Street and Boyle Avenue.

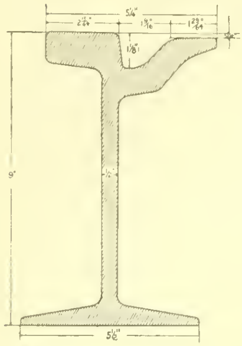
| | |
|---|---|
| Cost of dynamite charge per hole | $0.013 |
| Cost of exploder per hole | $0.0255 |

Four holes blasted in each four feet of track:

| | |
|---|---|
| Lineal feet of track blasted per hour | 138 |
| Cubic yards of concrete blasted per hour | 27.6 |
| Cubic yards of concrete blasted per pound of dynamite | 2 |
| Labor cost per cubic yard, blasted | $0.076 |
| Cost of dynamite and exploders per cubic yard, blasted | $0.192 |
| Cost of labor and material per cubic yard, blasted | $0.268 |
| Cost of blasting per lineal foot of track | $0.054 |
| Cost of blasting per mile of track | $285.12 |
| Cost of drilling and blasting per cubic yard | $0.353 |
| Cost of drilling and blasting per lineal foot of track | $0.071 |
| Cost of drilling and blasting per mile of track | $374.88 |

When the excavation was completed, the ties were placed in the trench, the rail spiked down, the tie rods pulled up to gage and temporary fishplates put on the joints. Work trains were then run on this track and the excavated material hauled away. The excavated material in this job amounted to 11 410 cu. yd., or 0.348 cu. yd. per lineal foot of track. The United Railways Company purchased a sink hole on North Grand Avenue and completely filled it with excavated material from Olive Street. All excavated material and all new material with the exception of the cement used in this work was handled on

cars, no teams being used at all. It would have been impossible to do the work in the time occupied had wagons and teams been depended upon.




United Railways Co. of St. Louis.
Section of 9" 112 lbs. Trilby Rail.

## Rail.

The rail used in this work was Lorain section 333, furnished in lengths of 60 ft. A cross-section is shown in the figure. The standard section has $\frac{7}{16}$-in. web, but it was considered desirable to have it rolled with $\frac{1}{2}$-in. web, and the rail with this change weighs 112 lb. per yd. Its height is 9 in., and the base is $5\frac{1}{2}$ in. The composition of the rail is as follows:

| | |
|---|---|
| Carbon | 0.55 per cent. |
| Silicon, not to exceed | 0.20 per cent. |
| Phosphorus, not to exceed | 0.10 per cent. |
| Sulphur, not to exceed | 0.10 per cent. |
| Manganese | 0.80 to 1.20 per cent. |

This carbon is unusually high, as girder rail of this weight seldom is rolled with carbon to exceed 0.45 per cent. The increase in carbon makes the rail much harder, but also much more likely to break. No trouble has been experienced from this source, however, only one rail having been broken in unloading. The head is what is known as the Trilby type, having a groove for the wheel flange and a turned-over lip for the street traffic. It is a very desirable rail head for street traffic, as vehicles can cross it without bumping, but any rail with a wagon tread has an extremely limited life. The depth of the groove in the rail is $1\frac{1}{8}$ in. The flange of the car wheel is $\frac{5}{8}$ in. deep. Therefore, whenever $\frac{1}{2}$ in. is worn off the head of the rail, the wheel is running on its flange and the rail is worn out for railway purposes, although it may be in perfect condition otherwise. This merely demonstrates the advantage of the T-rail, the use of which is unfortunately prohibited by our city ordinances.

## Ties.

The ties were of hewn cypress, 6 in. by 8 in. in section and 7 ft. long. It has been the usual practice in St. Louis to use white-oak ties, but it was considered that a soft wood tie en-

tirely embedded in concrete would be just as satisfactory as a hard wood tie. The ties were spaced two feet between centers. Tie plates were used under the rail, each alternate tie plate being a brace plate.

## Concreting.

After the excavated material had been hauled away and the street cleaned up, the track was lined and surfaced by means of wooden blocks and wedges placed beneath the ties. Concrete was then tamped beneath and around the ties, the concrete being deposited in the track from a concrete mixing machine running on the rails. The concrete used was composed of a mixture by volume of one part of Portland cement, 2½ parts of river sand and 6½ parts of crushed limestone rock. The cost (delivered) of the materials composing this concrete was as follows:

| | | |
|---|---|---|
| Crushed rock .......... | \$2.85 per square | = \$0.0285 per cu. ft.<br>= 0.77 per cu. yd. |
| Sand .................. | \$2.50 per square | = 0.025 per cu. ft.<br>= 0.675 per cu. yd. |
| Portland cement........ | \$1.70 per barrel | = 0.425 per sack. |

For the track work, 7.36 cu. ft., or 0.273 cu. yd., were required per lineal foot of track, 1¼ sacks of cement per lineal foot of track, or 1 650 barrels of cement per mile of track, were used in this work.

The value of the materials used (cement, rock and sand) was \$0.108 per cu. ft. of concrete, or \$2.92 per cu. yd. of concrete.

The material for the concrete was distributed on the street beside the tracks in advance of the machine, the sand being first deposited, then the crushed rock piled on that, and finally the cement sacks emptied on top of this pile. The materials were shoveled from this pile into the concrete mixing machine without any attempt at hand mixing on the street. Great care was taken in the delivery of materials on the street to have exactly the proper quantity of sand, rock and cement, so that there would be enough for the ballasting of the track to the proper height and that none would be left over. Each car was marked with its capacity in cubic feet, and each receiver was furnished with a table by which he could easily estimate the number of lineal feet of track over which the load should be distributed.

### Concrete Mixing Machines.

The concrete mixing machines were designed and built in the shops of the United Railways Company. Three machines were used in this work, one for each gang. The machine is composed of a Drake continuous worm mixer, fed by a chain dragging in a cast-iron trough. The trough is 36 ft. long, so that there is room for fourteen men to shovel into it. Water is sprayed into the worm after the materials are mixed dry. This water was obtained from the fire plugs along the route. In the first machine built, the Drake mixer was 8 ft. long. In the two newer machines the mixer was 10 ft. long. Both the conveyor and the mixer were motor driven, current being obtained for this purpose from the trolley wire overhead. Two types of machines were used, one in which the conveyor trough was straight and 45 in. above the rail, and the other in which the conveyor trough was lowered back of the mixer, being 25 in. above the rail. The latter type had the advantage of not requiring such a lift in shoveling, but the trough is so low that a motor truck cannot be placed underneath it. In the high machine the mixer is moved forward by a standard motor truck under the conveyor. In the low machine the mixer is moved by a ratchet and gear on the truck underneath the mixer. A crew of twenty-seven men is required to work each machine, and under average conditions concrete for 80 lineal feet of single track, amounting to 22 cu. yd., can be discharged per hour. The following figures give the average performance of the three machines in concreting the westbound track from Fourteenth Street to Boyle Avenue:

| | |
|---|---|
| Number of men employed at machine | 27 |
| Number of men shoveling into machine | 14 |
| Lineal feet of track concreted per hour | 80.95 |
| Cu. ft. of concrete discharged per hour | 595.79 |
| Cu. yd. of concrete discharged per hour | 22.06 |
| Labor cost of concrete per lineal foot of track | $0.071 |
| Labor cost of concrete per cu. yd. | $0.26 |
| Cost of materials composing concrete per lineal foot of track | $0.791 |
| Cost of materials composing concrete per cu. yd. | $2.92 |
| Total cost of concrete (labor and material) per lineal foot of track | $0.862 |
| Total cost of concrete (labor and material) per cu. yd. | $3.18 |
| Total cost of concrete (labor and material) per mile of single track | $4 551.36 |

In these figures there is no charge for electric power or for depreciation.

## Joints.

The rail joint adopted for this work was the cast-welded joint. This joint has been in use since 1896, the first use of it having been in this city. This method of joining rails has been the occasion of considerable debate among street railway engineers, the process having warm adherents and just as warm opponents. Without entering into a discussion of the matter, it will suffice to say that the process, when properly and carefully carried out, will produce excellent and permanent joints, and has the advantage of a reasonable cost where the work is done by the railway company as in this case. The process is an extremely simple one and consists merely in pouring melted cast iron into an iron mold placed around the abutting rail ends. The iron is allowed to harden, the molds knocked off and the joint is finished.

In performing the work, the fishplates which were temporarily placed on the joints for the lining and surfacing of the track are taken off and the rail ends thoroughly cleaned by means of a sand blast. Iron molds are then placed about the joint, a heavy screw clamp placed on the rail to keep it in perfect surface during the operation and melted iron poured into the mold. The iron is melted in a portable cupola, and consists of a mixture of one third selected scrap and two thirds soft charcoal iron. The secret of success with this process consists in thoroughly cleaning the rail ends, removing every particle of oxide, and in having the iron intensely hot when poured. Where these two precautions are taken, an actual welding takes place between the cast iron and the steel, a joint sawed in two showing an eating away of the base of the rail where the melted cast iron has struck it. Good joints have an electrical conductivity equal to, if not greater than, the same length of rail.

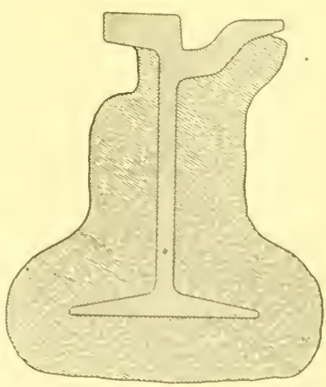


Fig. 17.

Objections have been made to this process on account of the heating of the head of the rail, it being stated that this heating anneals and softens the rail and causes it to wear away at this point. To prevent any annealing action, the molds used by the United Railways Company are so shaped that the cast iron is kept low on the back of

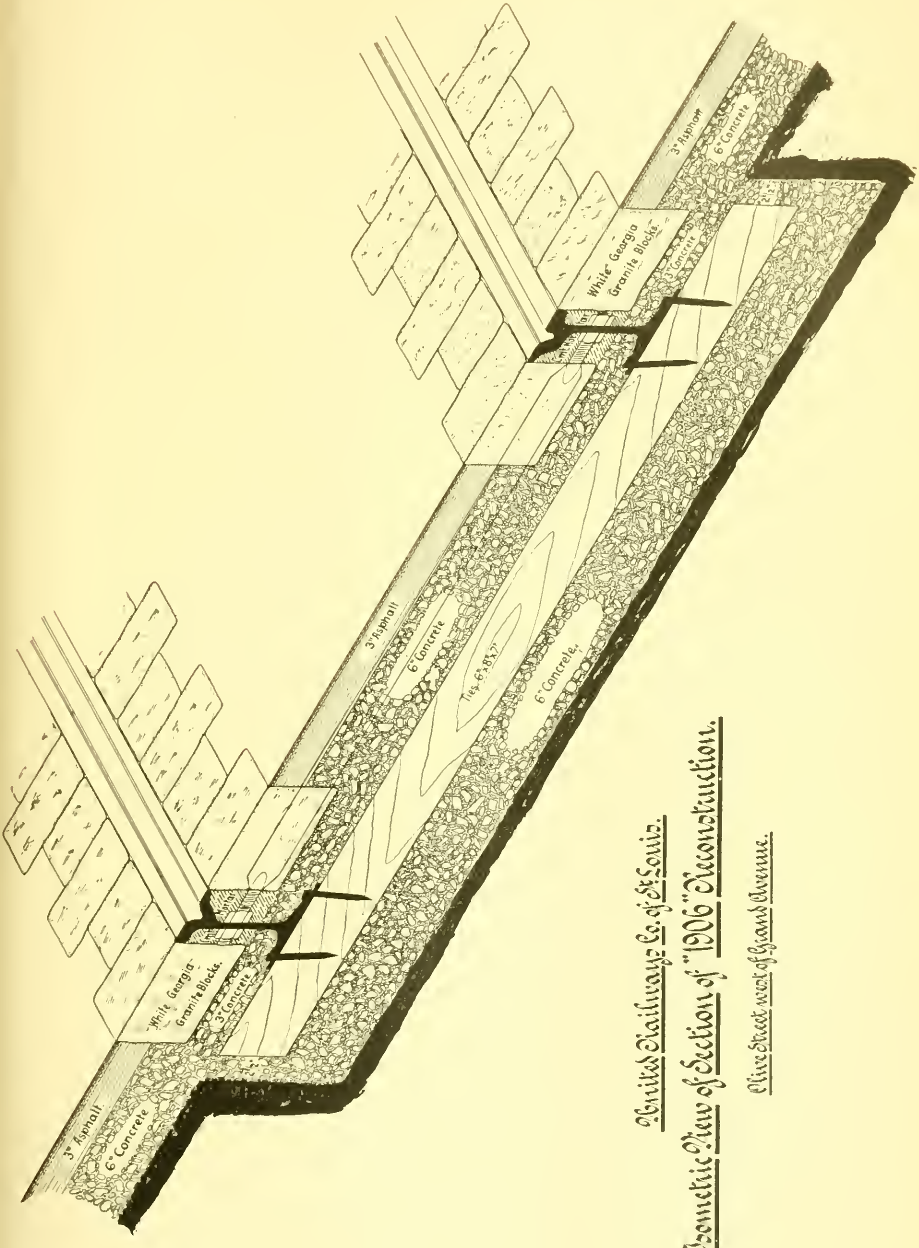
the rail, thus minimizing the heating of the rail head. The cast-iron joints used on the 9-in. rail shown in Fig. 17 weigh 170 lb., and the cross-sectional area is 65 sq. in. Assuming a tensile strength of 15 000 lb. per sq. in. for cast iron, the tensile strength of the joint is 975 000 lb., which indicates that the joint is stronger than the rail.

It is a source of wonder to laymen that miles of track in paved streets may be welded without any allowance for changes in length due to changes in temperature, and the question is often asked what becomes of the expansion and contraction of the rail. In answering this question, it should be remembered that the rail is embedded in a paving which soon packs so closely that any motion of the rail would be attended by great frictional resistance, and also that only 20 per cent. of the perimeter of the rail is exposed to the air, the rest of the rail being surrounded by a poor conductor of heat, so that the changes in temperature of the rail are not so violent nor are the extremes so great as those of the atmosphere. Nevertheless, there is a strain in the rail due to changes in temperature, and if there is no longitudinal motion to the rail, this strain is probably taken up in an infinitesimal change in the cross section of the rail.

In order to estimate what this strain amounts to, let us assume that the maximum deviation from the welding temperature is 75 degrees fahr., which is approximately correct for this climate. Assuming a coefficient of expansion of 0.000 000 5 for steel, a rail would contract, for a decrease of 75 degrees, 0.000 006 5 by 75, equal to 0.000 487 5 of its length. Assuming a modulus of elasticity of 30 000 000, this would correspond to a strain of 14 625 lb. per sq. in., which is well within the elastic limit of steel, showing that no harm is done by the alternate strains of tension and compression due to changes in temperature. As the cross-section of the rail is 11.2 sq. in., the pull in the rail due to contraction would be 11.2 by 14 625, equal to 163 800 lb., which is well within the tensile strength of the rail and the cast-welded joint.

## Paving.

The last process in the track construction was the paving. Olive Street east of Grand Avenue is a granite street, and the track was paved with granite blocks resting on a sand cushion 1 in. deep. West of Grand Avenue the street was asphalt, and the tracks were paved with 3 in. of asphalt laid on the concrete,




United Railways Co. of St. Louis.

Isometric View of Section of "1906" Reconstruction.

Olive Street west of Grand Avenue.

FIG. 18.

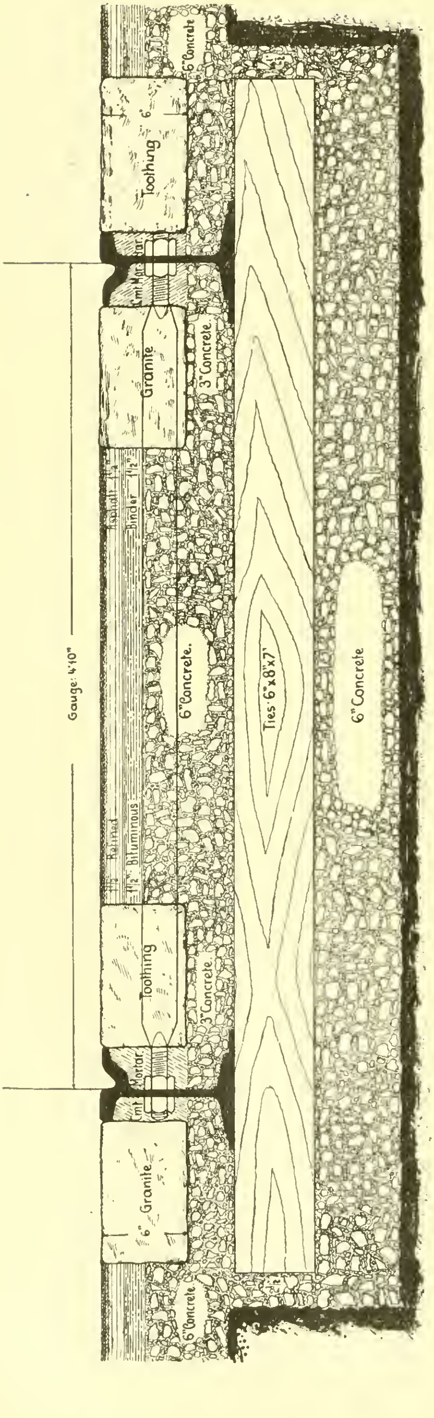



Fig. 19.

the asphalt being finished up against granite blocks set next the rails. This construction makes a smooth and sightly pavement. In all cases both sides of the rail were plastered underneath the head with a cement mortar, so that the paving blocks rested against a vertical surface and were prevented from sliding under the head of the rail. A cross-section of the finished track is shown in adjacent Fig. 19. and an isometric view in Fig. 18.

After the concrete work was finished, the concrete was allowed seven days to set before cars were allowed to run over it. This interval sufficed for the paving, so that the track was entirely finished before it was opened for traffic.

## Speed of Construction.

The United Railways Company officials are especially proud of the speed with which this difficult work was performed. For the section between Fourteenth Street and Boyle Avenue (5.51 miles), work was begun April 30, 1906, and the cars were turned back on the street on June 11, 1906, exactly six weeks having elapsed

since ground was broken. Of this time, two weeks were allowed for the setting of the concrete, so that the entire work, with exception of the paving, was done in four weeks, which is an average of 1 040 lineal feet of single track (0.20 miles) per day. The cost of this 5½ miles of track was about $170 500. For the entire work, after making the credits for scrap material from the old track, the average cost per mile of completed track was about $27 000.

### Durability of Track.

In the track construction adopted by the United Railways Company only the best materials are used, and by the use of a concrete foundation it is hoped to obtain the most substantial and durable construction possible, and one which will maintain the street paving in good condition. The question is often asked how long such a track as that laid on Olive Street will last. Of course the wear on a track is directly proportional to the number of cars run over it. As has already been stated, the type of rail used in this construction is worn out for railway purposes when the wheel flange runs on the rail, which will occur when about ¾ in. is worn off the head of the rail. It is hoped that with the rail supported so firmly as in this case, so that there is no deflection as the car wheel passes over it, the rail wear will be minimized, but with the heavy traffic of this street, it is doubtful if the rail will have a life of more than ten years. The roadbed itself, however, should outlast several sets of rails. The ties are entirely embedded in concrete and are not subject to decay, and it is proposed that when the present rails are worn out, new rails shall be put down on the same roadbed, making the matter of renewing the rails a comparatively inexpensive process.

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[Note. Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by November 15, 1906, for publication in a subsequent number of the Journal.]

## OBITUARY.

### Eddy Elbert Young.

MEMBER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

EDDY ELBERT YOUNG, son of Enoch Young and Cordelia Young, was born in 1865 in Wapun, Wis. In 1867 his parents took him from Wapun to Lowell, Mass., in which city he spent his boyhood.

As will be seen in the outline of his professional work given below, he began at the age of sixteen. He had then gone only partly through the Lowell High School, but after he started work he continued his schooling by studying mechanical and architectural drawing for several winters in an evening class. He was quick of apprehension and thus got more than most boys from his brief schooling. His choice to leave school at the early age he did was later a source of regret. His regret was, to a considerable degree, needless, for by his private study and his close and accurate observation he became in many respects a man of culture as well as an advancing engineer. At the time of his early death he had already done much good work and showed every indication of doing even better.

The following is an outline of his professional career, the account being, in part, taken from the information furnished at the time of his becoming an associate member of the American Society of Civil Engineers :

Spring and summer, 1881, draftsman and rodman, Merrimack Manufacturing Company (mill engineering): May, 1883, to April, 1884, draftsman and rodman with Melvin B. Smith, C.E. and Surv.: remainder of 1884, draftsman and transitman on short engagements of a miscellaneous character: March, 1886, to May, 1888, draftsman and transitman, New York & New England Railroad: September, 1888, to March, 1889, draftsman, transitman and inspector, Boston & Maine Railroad, on construction, Mystic terminal grounds: summer, 1889, assistant with George H. Barney, C.E. and Surv., Hyde Park, Mass.: autumn 1889, to spring, 1890, assistant and inspector with Percy M. Blake, C.E., on construction, Andover Water Works, Andover, Mass.: spring and summer, 1890, assistant with city of Newton

EDDY ELBERT YOUNG.

(Albert F. Noyes, city engineer), on assessors' maps, drafting, surveying, computing, etc.: September, 1890, to October, 1894, draftsman and transitman, Metropolitan Sewerage Commission of Massachusetts, office, surveys and construction of North Metropolitan and Charles River systems, including compressed air tunnel work, etc.: October, 1894, to March, 1898, assistant engineer, Boston Transit Commission, on Boston subways, designs for ventilating chambers: grading, sewers, etc., for Boston Common: tunnels under thoroughfares; pile foundations, Public Garden incline: April, 1898, to January, 1899, assistant engineer, on sewer assessment, city of Boston; February to April, 1899, assistant engineer, Boston Elevated Railway on designs for masonry structures: June, 1899, to August, 1903, assistant engineer, Metropolitan Sewerage Commission of Massachusetts, on high-level sewer, surveys, mapping same, tunnel construction in rock and earth (compressed air used to advance headings in quicksand): August, 1903, to June 30, 1904, engineer of alignment on Hudson Tunnel, in charge of triangulation, lines, grades, etc., under Jacobs & Davies, consulting engineers: August, 1904, to January 31, 1906, in charge of drafting for the O'Rourke Engineering Construction Company, New York City: February 1, 1906, to the time of his death, June 1, 1906, engineer and manager of the New York work of the Healey Sewer Machine and Construction Company, land and subaqueous borings for various railroads, the New York Rapid Transit Railroad Commission and for the additional water supply for New York.

It is pleasant to recall that the excellent character of Mr. Young's work was meeting with substantial reward. An instance of this was the bonus of $500, with which he was presented by his employers, Messrs. Jacobs & Davies, on the meeting of the Hudson River Tunnel headings for whose alignment he was responsible. The letter of transmittal, which also informed him of an increase in salary, spoke of the check as " some appreciation " of the value of Mr. Young's work and the untiring energy he had always shown in the interests of the tunnel company.

February 6, 1897, he married Miss Alice Frances Carter, of Charlestown, Mass., who survives him with their two children.

Mr. Young's physical condition, for some years prior to his death, had been such as to call for a serious surgical operation. His very energy and ambition here worked against him, leading him to delay too long in seeking surgical relief. In April, 1906, however, he came back to Boston, where the necessary operation

was performed on the 6th of that month in a private hospital. On the 25th of April he went back to business in New York, but at the end of two days he was forced to leave off. He returned to his home in Auburndale, May 19, and his death occurred in that town. The immediate cause of his death was acute nephritis, but the original cause was his extreme devotion to work which led him to forget himself too completely.

The burial was in Lowell, Mass.

Mr. Young's tastes were fine, as evinced by his fondness for music, his talent for artistic drawing and modeling, and his appreciation of the beautiful in form and color.

Many will feel that by his death they have lost a valued friend. The engineering profession has lost a member who was ambitious and who was earnest in whatever he undertook and who did all his work with honesty, truthfulness and ability.

H. A. Carson.

# ASSOCIATION OF ENGINEERING SOCIETIES.

Organized 1881.

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## THE RELATION OF THE SUSPENDED MATTER IN SEWAGE TO THE PROBLEM OF SEWAGE DISPOSAL.

BY HARRISON P. EDDY AND ALMON L. FALES.

[Read before the Sanitary Section of the Boston Society of Civil Engineers, October 3, 1906.]

ONE of the most troublesome features of the problems relating to the disposal of sewage is the control or removal of the matters carried in suspension.

An early consideration, and one of no mean importance in the design of a sewer system, is that of affording conditions which will insure the conveyance of solid particles regularly with the flow of the sewage. This is accomplished, as is well known, by means of the slope given to the sewers, which is so regulated as to provide a velocity of flow sufficient to carry these matters in suspension. Where such slope cannot be had for topographical reasons various substitute methods are provided to accomplish the same purpose.

Again, in pumping, special and often elaborate provisions are made for removing from the sewage the sand and coarser matter in suspension for the preservation and effective maintenance of the machinery.

In the discharge of sewage into water courses, lakes and tide-waters, an important consideration is the effect of the solids which float upon the surface of the water or which settle to the bed of the stream or the bottom of the lake or bay.

The problems of sewage treatment are naturally separated into two general groups,— those dealing with the liquid and soluble portion, and those having to do with the solids floating or carried in suspension.

It has come to be very generally recognized that the latter group of problems constitutes the more difficult and expensive part of the treatment. With the satisfactory solution of such questions sewage disposal would be very greatly simplified.

It is the purpose of this paper to present some of the results of the practical operation of various methods of sewage purification at the disposal works in the city of Worcester, Mass., with the view of placing on record some information bearing directly upon this subject.

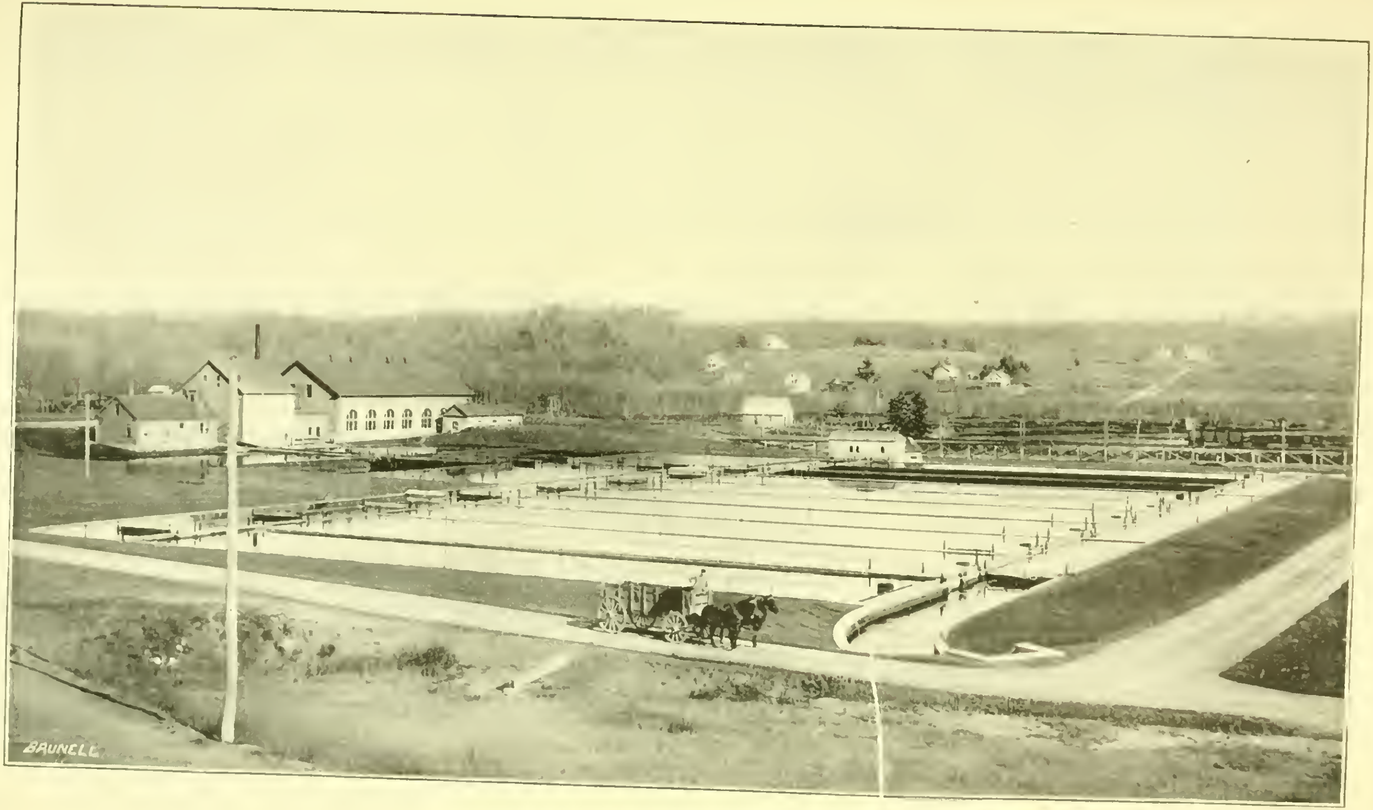
In 1890 a small chemical precipitation plant was put into operation, consisting chiefly of six settling basins, lime house, power plant and laboratory. This equipment was designed to treat about 3 000 000 gallons per day. In 1893 the number of settling basins was increased to 16, each holding 350 000 gal.

The first sewers were built under special authorizing statute in 1867, and from that time until 1901 the sewage was discharged into a natural stream passing through the city from north to south, and having a watershed above the sewer district of about 7 sq. miles. This brook has for a number of years been controlled by a storage reservoir and the waters drawn in fairly uniform quantity for manufacturing purposes. The dry weather flow rarely dropped below 3 000 000 gal., with an average of about 5 000 000 gal., while occasionally the spring discharge ran up to 60 000 000 or 70 000 000 gal. per day.

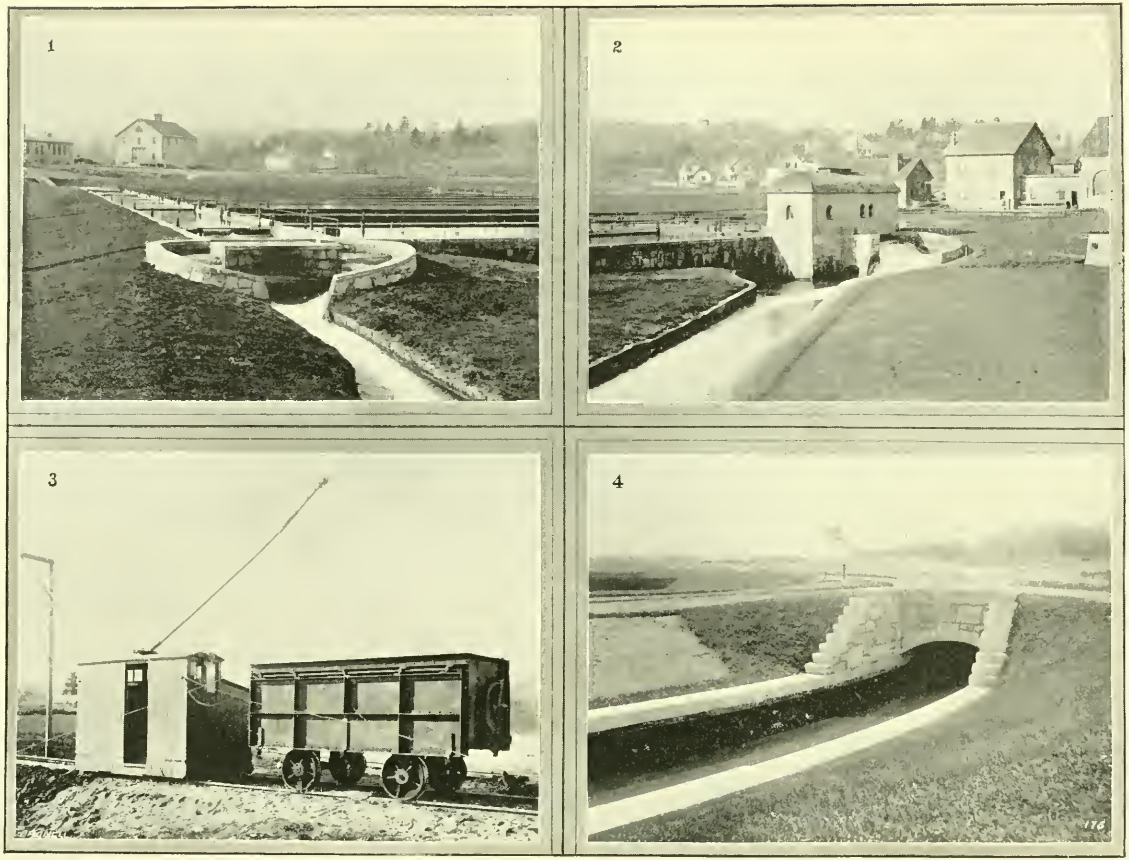
At the time the disposal plant was built the sewer system was almost wholly on the combined plan, the drainage area being about 5 sq. miles. With the 16 settling basins the dry weather flow of sewage, amounting to about 16 000 000 gal. daily, could be treated, but any material increase in flow, due either to storm water or to greater draft from the controlling reservoir on the brook, caused an overflow into the river of water which could not be taken to the purification works because of the limited capacity of the outfall sewer.

For a number of years the sludge, resulting from the chemical treatment, was pumped directly from the settling basins on to adjacent fields, where it was allowed to drain and dry. Some of it was used for fertilizer and some burned, but a very large amount simply remained where it was delivered by the pump and is still on hand, although grassed over and yielding a profitable crop of hay each year.

This method of sludge disposal being unsatisfactory in many ways, a sludge pressing plant was built in 1898. With this machinery the sludge has been pressed immediately after pump-




PRECIPITATION PLANT, WORCESTER, MASS.



VIEWS AT PURIFICATION WORKS, WORCESTER, MASS. 1. SPILLWAY. 2. SPILLWAY AND COMPRESSOR HOUSE.
3. MOTOR CAR WITH SLUDGE CAR ATTACHED. 4. ENTRANCE TO CONDUIT LEADING TO FILTER BEDS.

ing, and hauled by electric cars to a dump about three quarters of a mile away.

Worcester maintained an average growth during 50 years amounting to an increase of about 20 per cent. of its population every 5 years. This rate of growth has not been maintained, however, during the last 5 years, according to the state census.

Increasing size has required the continued enlargement of the water system, and thus far all the water supplied to the city has been taken from streams tributary to the Blackstone River, into which the sewage is discharged after treatment. The river above the purification works has accordingly decreased in size from year to year, thus furnishing a smaller quantity of pure water for dilution of the sewage and sewage effluents.

In 1901 two intercepting sewers were completed and now receive the sewage through automatic regulating gates. In time of storm, after the outfall sewer becomes filled to its capacity, these gates allow the surplus of storm water and sewage to overflow into the brook. This overflow of untreated sewage occurs only in time of actual storm or melting snow.

From the time when it was decided to build a plant for sewage treatment, all new sewer districts have been provided with the separate system, and at the present time the sewer system consists of 72.95 miles of separate sewers, 62.248 miles of combined sewers, these two systems being tributary to the disposal works; and 41.607 miles of surface water drains having no connection with the outfall sewer.

The small flow of the Blackstone River (drainage area, 57.07 sq. miles) and the increasing proportion of sewage effluent made it evident that eventually it would be necessary to treat the sewage more thoroughly than was possible by means of chemical precipitation, and accordingly the city began the construction of sand filters in 1898 and has increased this part of the plant from time to time, until there are now 36 acres of actual filtering area.

These filters have received crude sewage and the effluents from the chemical and septic treatments, and from simple sedimentation.

All of the processes which have been used on a practical scale have been affected by the solids suspended in the sewage. In each case a waste material has been produced consisting of liquid sludge resulting from the preliminary treatments, and of dry or nearly dry accumulations on the filters.

The sewage received at the disposal works contains large quantities of manufactural wastes, the most important being that from the tanneries and from various wire-drawing establishments. A fair idea of the quality and quantity of sewage dealt with during the past twelve years may be obtained by an examination of Table I.

About one third of the total residue on evaporation is suspended matter, and of the suspended matter one half to two thirds is organic and volatile.

The figures for solids for 1901, 1902 and 1903 given in the table are taken from the analyses of the sewage entering the septic tank, and as all storm water was carefully excluded the suspended solids are somewhat lower and the proportion of organic and volatile matter somewhat higher than the average sample of all sewage would give.

It will be noticed that the suspended albuminoid ammonia is usually higher than the dissolved. This difference becomes more marked during the last five years, which may be explained largely by the fact that the intercepting sewers were in use. Previous to this time large quantities of the suspended solids settled out of the sewage during its passage through the brook channel into which it was discharged and from which it was diverted into the outfall sewer by means of a dam. At times of high water the increased velocity of flow in the brook carried much of the deposit directly into the river.

It is also true that beginning at about the same time analyses were made in weekly samples, made up of sterilized daily portions, and in spite of sterilizing more or less of the soluble and colloidal matters was precipitated.

Beginning with 1905, however, the samples were filtered as soon as taken, thus assuring accuracy in the determination of the proportion of suspended to dissolved solids.

Throughout this discussion the costs given include the entire cost of supervision, clerical services, laboratory expenses, including all experimental work, as well as the repairs on the plant, but do not include interest on the original investment.

### Grit Chambers.

In 1904, 2 grit chambers were built, each being 10 ft. wide, 40 ft. long and providing for a depth of about 9 ft. of sewage and silt. They were constructed side by side on the line of the 42-in. outfall sewer, and so arranged that the sewage could

## TABLE I.

### Analysis of Worcester Sewage.

(Parts per 100,000.)

| Date. | Residue on Evaporation. | | | | | | | | | Ammonia. | | | | Oxygen Consumed in 2 Min. at 100° Cent. | | Chlorine. | Average Flow Treated in Million Gallons per Day (365 Days). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total Residue. | | | Volatile Residue. | | | Total Residue. | | | | Albuminoid. | | | | | | |
| | Total. | Dissolved. | Suspended. | Total. | Dissolved. | Suspended. | Total. | Dissolved. | Suspended. | Free. | Total. | Dissolved. | Suspended. | Unfiltered. | Filtered. | | |
| July 19 to Dec. 1, 1893 | 62.8 | 43.5 | 19.3 | 28.3 | 16.5 | 11.8 | 34.5 | 27.0 | 7.5 | 1.305 | .536 | .266 | .270 | 5.17 | 2.85 | 6.05 | 4.92 |
| Year ending Dec. 1, 1894 | 60.4 | 37.4 | 23.0 | 23.3 | 12.5 | 10.8 | 37.1 | 24.9 | 12.2 | 1.073 | .506 | .248 | .258 | 4.05 | 2.60 | 5.66 | 12.49 |
| " " " 1895 | Residue on evaporation not determined (1895–1900). | | | | | | | | | 1.160 | .518 | .249 | .270 | 5.27 | 2.91 | 5.98 | 15.70 |
| " " " 1896 | | | | | | | | | | 1.118 | .497 | .246 | .251 | 4.63 | 2.47 | 5.50 | 16.00 |
| " " " 1897 | | | | | | | | | | 1.108 | .478 | .233 | .245 | 4.23 | 2.12 | 5.87 | 17.00 |
| " " " 1898 | | | | | | | | | | 0.851 | .438 | .221 | .217 | 4.03 | 2.17 | 4.76 | 17.68 |
| " " " 1899 | | | | | | | | | | 1.007 | .480 | .237 | .243 | 5.63 | 3.24 | 5.87 | 17.10 |
| " " " 1900 | | | | | | | | | | 1.368 | .527 | .240 | .287 | 6.90 | 4.75 | 6.78 | 13.10 |
| " " " 1901 | 87.9 | 55.3 | 32.6 | 46.3 | 26.0 | 20.3 | 41.6 | 29.3 | 12.3 | 1.786 | .632 | .255 | .377 | 8.83 | 5.81 | 7.21 | 9.77 |
| " " " 1902 | 83.2 | 52.2 | 31.0 | 41.6 | 24.0 | 17.6 | 41.6 | 28.0 | 13.4 | 2.050 | .810 | .252 | .558 | 11.02 | 6.83 | 8.43 | 13.27 |
| " " " 1903 | 81.4 | 52.6 | 28.8 | 41.7 | 23.8 | 17.9 | 39.7 | 28.8 | 10.9 | 1.769 | .832 | .288 | .544 | 9.39 | 5.36 | 9.[illegible]4 | 15.55 |
| " " " 1904 | | | | | | | | | | 1.955 | .840 | .318 | .522 | 10.05 | 6.15 | 10.23 | 12.03 |
| " " " 1905 | 90.2 | 68.5 | 21.7 | 50.7 | 34.6 | 16.1 | 39.5 | 33.9 | 5.6 | 2.035 | .926 | .377 | .549 | 11.96 | 7.54 | 11.04 | 11.83 |

be turned through one or through both at the same time, as was deemed best.

Experience has proved that with the ordinary flow of sewage, say up to 15 000 000 gal. per 24 h., too much organic matter is settled out if both basins are in operation. When storm water is mingled with the sewage, at which time the rate of flow is generally above 15 000 000 gal., it has been found necessary to allow the flow to pass through both chambers to insure the collection of substantially all of the sand and gravel.

Following is a schedule of some of the important statistics gathered from the operation of the grit chambers through a period of something over a year.

Grit Chamber Statistics.

| | Customary Use of Chambers. | Two Chambers in Use at Rates below 15 000 000 Gal. |
|---|---|---|
| Deposit per million gallons sewage passed through chamber... | 0.16 cu. yd. | 0.52 cu. yd. |
| Cost of cleaning chambers and hauling refuse 1 000 ft. ...... | $0.81 per cu. yd. | $0.95 per cu. yd. |
| Cost of cleaning chambers and hauling refuse 1 000 ft. (per million gallons sewage passed through basin).............. | $0.13 | $0.51 |
| Dry solid matter contained in refuse ..................... | 50 per cent. | 30 per cent. |
| Volatile (loss on ignition) matter contained in refuse........... | 35 per cent. | 50 per cent. |
| Organic nitrogen in dry solid matter..................... | 0.75 per cent. | 1.00 per cent. |
| Weight of refuse as removed from chambers .................. | 67.2 lb. per cu. ft. | |

In the consideration of the above figures it should be remembered that there was comparatively little storm water received during the year. This fact would probably not materially affect the amount of refuse per million gallons or the cost of removing the same, but would doubtless affect its weight and the proportion of mineral and organic constituents.

A very offensive odor was always given off from the sludge when it was being removed from the basins and for some time after it had been spread upon the dump. This is a matter deserving serious consideration when the location for grit chambers is to be selected.

No special machinery has been installed for handling this material, it being shoveled out of the basins by hand and hauled away in tip carts.

Removing Heavy Deposit from Precipitation Basin before Grit Chambers were Constructed, Worcester, Mass.

### Sludge Resulting from Chemical Precipitation.

As has already been pointed out, Worcester sewage contains large quantities of pickling liquids. These are present to such an extent that they have a very material effect upon the sludge which is produced in the settling basins. The only chemical added to the sewage is lime, there being present at nearly all times sufficient copperas to insure a good treatment, although there is not always enough to completely remove the coloring matter when the sewage contains very large quantities of refuse from the tanneries and from the dye works. When the lime is added to the sewage the iron is thrown out of solution in the form of a flocculent precipitate. This settles to the bottom of the basins, together with the suspended matter carried in the sewage, and forms the sludge.

The amount of sludge formed depends not merely on the amount of suspended matter in the sewage, but is governed largely by the amount of dissolved iron present; consequently the amount and character of the sludge vary during different portions of the day and at different periods, depending on the condition of business in general, and particularly on that of the iron and steel industries.

During the first part of storms the sludge deposited is very heavy, owing to road detritus. The grit chambers which have recently been built retain much of this material, which is removed and taken directly to the dump. With this arrangement the sludge in the settling basins has become more uniform in character, and more easily pumped and pressed.

It is a well-known fact that the sludge resulting from chemical precipitation decomposes on standing in the same way as does the crude sewage sludge of the septic tank. During the warm weather the evolution of gas is quite violent unless the sludge is removed from the basins at frequent intervals. Portions of the sludge, which for a time retain the gas after it is generated, are carried to the surface, where a part remains, the rest settling again to the bottom of the basin. If this process is allowed to become very general throughout the basins the effluent resulting from the treatment will contain an abnormal quantity of suspended solids. It has been found advantageous to remove the sludge from the roughing tanks about once in two weeks, and from the finishing tanks about once in four weeks.

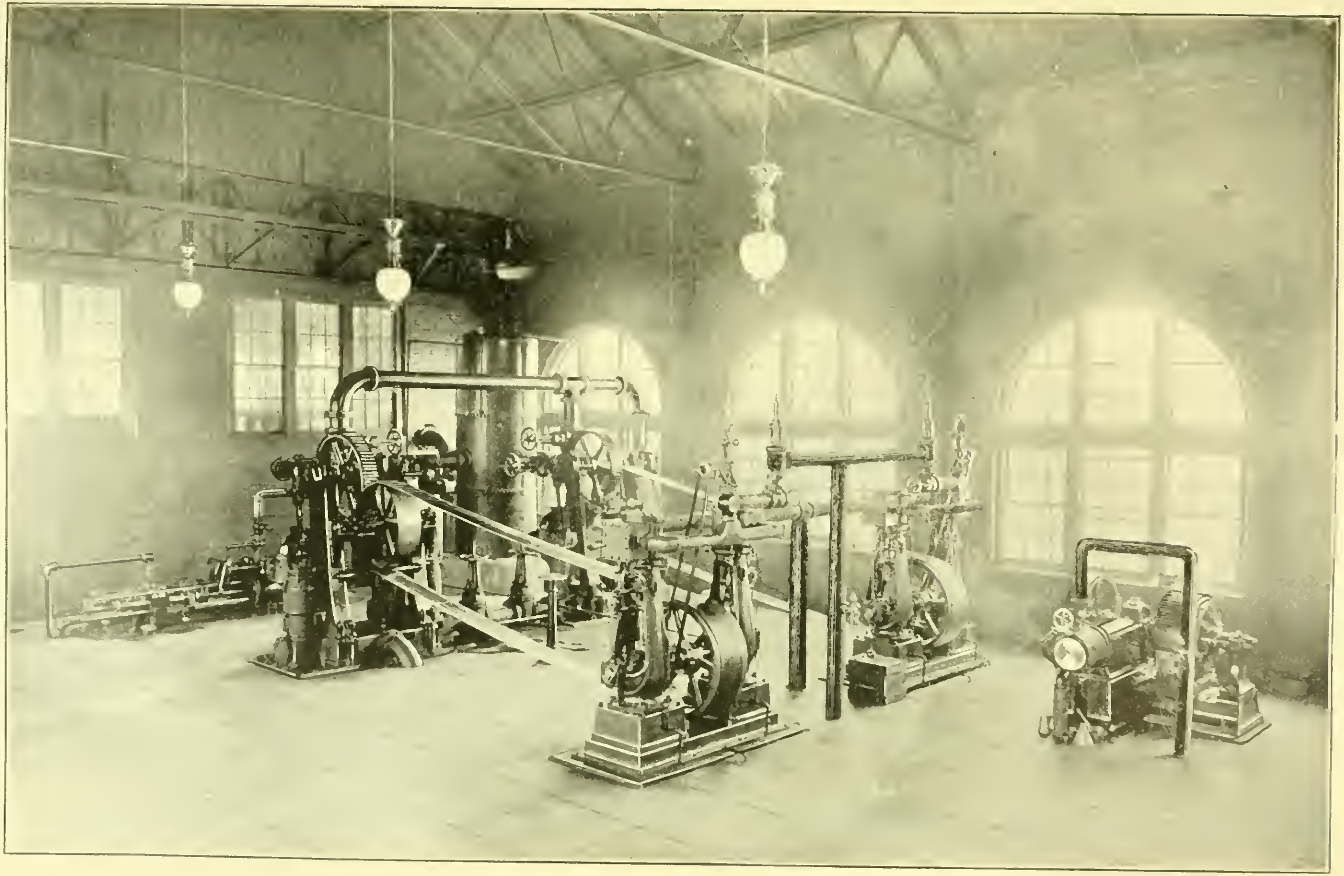
The following table is a compilation of various statistics collected during 15 years of the operation of the Worcester plant:

## TABLE II.

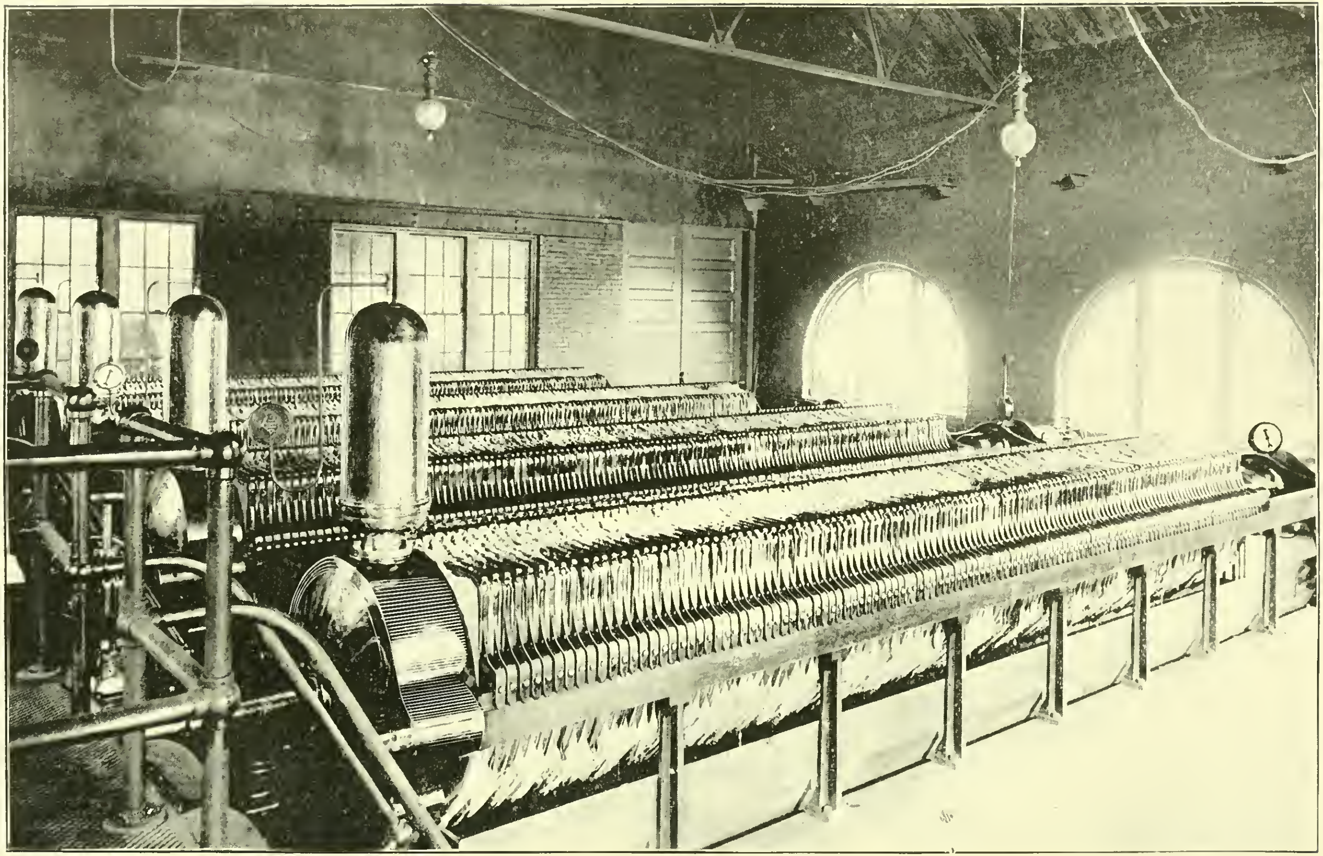
### Data on Sludge Resulting from Chemical Precipitation.

| Year. | Average Flow of Sewage Treated in Million Gallons per Day (365 Days). | * Lime Used in Chemical Treatment Lb. per Million Gallons Sewage Treated. | Volume of Sludge Pumped from Settling Basins. | | Solids in Sludge Pumped from Settling Basins. | |
|---|---|---|---|---|---|---|
| | | | Gallons per Million Gallons Sewage Treated. | Relation to Volume of Sewage Treated. | Per Cent. of Solids in Sludge. | Tons of 2 000 Lb. per Million Gallons Sewage Treated. |
| | | | | Per Cent. | | |
| 1891 | 3.83 | 965 | 15 760 | 1.6 | 1.33 | 0.88 |
| 1892 | 2.30 | 1 079 | 13 780 | 1.4 | 1.33 | 0.76 |
| 1893 | 4.92 | 1 170 | 10 970 | 1.1 | 2.88 | 1.31 |
| 1894 | 12.49 | 941 | 10 280 | 1.0 | 2.88 | 1.23 |
| 1895 | 15.70 | 1 030 | 11 600 | 1.2 | 2.88 | 1.39 |
| 1896 | 16.00 | 1 212 | 11 060 | 1.1 | 2.61 | 1.20 |
| 1897 | 17.00 | 1 130 | 10 730 | 1.1 | 2.61 | 1.17 |
| 1898 | 17.68 | 1 073 | 7 820 | 0.8 | 2.61 | 0.85 |
| 1899 | 16.35 | 1 204 | 11 230 | 1.1 | 2.99 | 1.40 |
| 1900 | 10.10 | 1 373 | 11 260 | 1.1 | 4.42 | 2.08 |
| 1901 | 8.58 | 1 498 | 8 638 | 0.9 | 4.85 | 1.75 |
| 1902 | 12.54 | 1 005 | 4 935 | 0.5 | 7.41 | 1.52 |
| 1903 | 14.39 | 871 | 4 809 | 0.5 | 7.23 | 1.45 |
| 1904 | 11.55 | 1 005 | 6 392 | 0.6 | 6.24 | 1.65 |
| 1905 | 10.11 | 999 | 4 950 | 0.5 | 8.28 | 1.71 |

* Lime added to sludge to facilitate pressing not included.



Engine-room, Showing Engines and Pumps, Pressure Tank, Hydraulic Pump, and Direct Connected Engine and Dynamo, Worcester, Mass.



Sludge Filter Presses, Worcester, Mass.

The difference between the quantity of sewage treated in the years previous to 1900 and the following years is accounted for by the partial change from the combined system to the separate system, the completion of two main intercepting sewers, by means of which a large amount of brook water was excluded from the sewage, and a certain amount of untreated sewage turned directly on to the filter beds.

### Sludge Pressing.

The sludge pressing plant consists of the necessary pumping machinery and 4 filter presses, each containing 125 circular chambers 36 in. in diameter and 0.75 in. wide. The sludge is pumped from the precipitation basins into storage tanks. After settling, the clear water is drawn off, and the sludge pumped by power plunger pumps into the filter presses under 80 lb. pressure to the sq. in. The presses are closed by hydraulic rams. The sludge cake is stripped from the filter cloths and allowed to fall into conveyors, which deliver it into cars. It is then hauled by motor car to a sludge dump located about three quarters of a mile from the press house. When sludge is very fresh, and consequently quite thin, the presses do not fill as rapidly as when it has become denser. It is, therefore, usually allowed to remain in the settling basins until it reaches a density of from 4 to 7 per cent. solids.

From 20 to 30 lb. lime per 1 000 gal. are required to facilitate the pressing of comparatively fresh sludge. As septic action becomes well established, however, the difficulty experienced in pressing is greatly increased, and much more lime is needed, reaching as high as 100 lb. per 1 000 gal. pressed.

Table III is a statement of the results obtained by the sludge-pressing plant during the 7 years in which it has been in use:

TABLE III.

RESULTS OF SLUDGE PRESSING, 1899 TO 1905.

| Year. | Gallons Sludge Pressed per Day (365 Days). | Sludge Cake Produced. | | Dry Solids in Cake. | | Lime Added to Sludge to Facilitate Pressing. | | Cost of Pressing, Hauling and Dumping Sludge. | |
|---|---|---|---|---|---|---|---|---|---|
| | | Cubic Yards per Million Gallons Sewage Treated. | Tons of 2 000 Lb. per Million Gallons Sewage Treated. | Per Cent. of Dry Solids in Cake. | Tons of 2,000 Lb. per Million Gallons Sewage Treated. | Pounds per Thousand Gallons Sludge. | Pounds per Million Gallons Sewage Treated. | Per Million Gallons Sewage Treated. | Per Ton of Dry Solids in Cake. |
| 1899...... | 144 100 | 6.2 | 5.3 | 26.1 | 1.07 | 11.1 | 93.6 | $4.92 | $4.64 |
| 1900...... | 108 100 | 8.7 | 7.4 | 28.0 | 1.98 | 21.2 | 226.6 | 6.76 | 3.42 |
| 1901...... | 68 280 | 7.6 | 6.5 | 27.0 | 1.75 | 20.0 | 159.7 | 5.89 | 3.39 |
| 1902...... | 57 270 | 5.7 | 4.8 | 31.6 | 1.52 | 30.3 | 149.6 | 5.20 | 3.41 |
| 1903...... | 67 200 | 5.6 | 4.8 | 30.3 | 1.45 | 33.5 | 161.1 | 4.91 | 3.39 |
| 1904...... | 66 660 | 6.8 | 5.7 | 28.9 | 1.65 | 28.5 | 180.1 | 5.83 | 3.51 |
| 1905...... | 45 070 | 5.9 | 5.3 | 32.2 | 1.71 | 53.5 | 265.1 | 6.33 | 3.71 |

## Sludge Resulting from Plain Sedimentation.

During the years of 1902 and 1903 several experiments were made to ascertain the degree of purification attained and the quantity of sludge that would be deposited on passing sewage at different rates through a basin 40 ft. by 166.666 ft. by 7 ft. deep, holding about 350 000 gal. Cofferdams, 2 or 3 ft. high, were built across the basin, dividing it into four equal compartments. Directly above these were scum boards extending 18 in. below the surface of the water, and projecting above it about 8 in.

The sewage was admitted from a trough extending across one end of the basin, by means of apertures about 12 in. apart, and 18 in. below the surface. A box extended entirely across the other end of the basin, one side of which was depressed so that the effluent flowed over it in a stream of uniform depth throughout its length. A scum board was attached to this box which prevented the scum from passing out with the effluent. By means of these boxes the flow was distributed across the basin as uniformly as possible. The sewage passed continuously through the tank, except at times when storm water was present to a very noticeable extent.

It was the aim in these experiments to adhere as closely as possible to plain sedimentation, and not to allow complication through septic action. Before the basin showed signs of marked septic action, from 4 to 8 weeks according to the weather, the water was drawn off, and the sludge measured, removed and analyzed.

It was, of course, impossible to stop the periods at exactly corresponding points, and there was more bacterial action at the end of some periods than of others. There was always, however, a decided difference in the appearance of the sedimentation and septic basins, which were side by side. The evolution of gas was less violent, the effluent was lighter colored and there was less odor in the case of the sedimentation tank.

There was very little scum on the sedimentation tank when the periods were terminated. In cold weather, even after a period of 8 weeks, there was more contrast in the appearance of the two tanks than there was in warm weather at the end of a very short time.

The results of these experiments, in relation to the sludge problem, are given in Table IV.

TABLE IV.

DATA ON SLUDGE RESULTING FROM SEDIMENTATION.

| No. | Duration of Period. | Nominal Rate per Day in Gallons. | Volume of Sludge Pumped from Settling Basin. | | Solids in Sludge as Pumped from Settling Basin. | |
|---|---|---|---|---|---|---|
| | | | Gallons per Million Gallons Sewage Treated. | Relation of Volume Sludge to Volume Sewage. | Per Cent of Solids in Sludge. | Tons of 2 000 Lb. per Million Gallons Sewage. |
| | | | | Per Cent. | | |
| 1 | April 5 to May 5, 1902 | 300 000 | 1 721 | 0.17 | 11.06 | 0.80 |
| 2 | May 23 to June 28, 1902 | 300 000 | 3 596 | 0.36 | 6.18 | 0.93 |
| 3 | July 9 to August 2, 1902 | ½ at 300 000<br>½ at 400 000 | 3 625 | 0.36 | 6.43 | 0.97 |
| 4 | August 3 to September 1, 1902 | 400 000 | 3 581 | 0.36 | 4.72 | 0.70 |
| 5 | September 6 to October 7, 1902 | 500 000 | 3 556 | 0.36 | 5.27 | 0.78 |
| 6 | October 8 to November 1, 1902 | 600 000 | 2 708 | 0.27 | 6.65 | 0.75 |
| 7 | December 21, 1902, to February 7, 1903 | 750 000 | 1 074 | 0.11 | 4.16 | 0.19 |
| 8 | February 8 to March 20, 1903 | 750 000 | 1 559 | 0.16 | 7.40 | 0.48 |
| 9 | March 21 to May 1, 1903 | 750 000 | 860 | 0.086 | 7.48 | 0.27 |
| 10 | May 3 to May 31, 1903 | 750 000 | 1 901 | 0.19 | 4.17 | 0.33 |
| 11 | June 6 to July 2, 1903 | 750 000 | 2 150 | 0.22 | 3.15 | 0.28 |
| 12 | August 17 to September 12, 1903 | 1 000 000 | 1 789 | 0.18 | 3.38 | 0.25 |
| 13 | September 16 to October 24, 1903 | 1 000 000 | 1 439 | 0.14 | 3.89 | 0.23 |

It will be seen that there is a wide variation in the quantity of sludge produced by sedimentation at the different rates of flow. This is a natural result of varying velocity, but the figures cannot be taken too literally, as the variation in the quality of sewage, and also to a less extent the length of period and temperature, doubtless had a material effect.

During periods 1 and 9 the sewage was largely diluted with surface water. While storm water during actual rain was not allowed to pass through the tank, some street detritus was unavoidably admitted. These facts account both for the smaller volume of sludge and for its greater density during these periods. Leaving out periods 1 and 9, which are obviously abnormal in these two respects, the data in Table V are obtained:

TABLE V. Amount of Sludge Resulting from Sedimentation at Different Rates.

| Periods Averaged. | Flow of Sewage per Day in Gallons. | Gallons per Million Gallons Sewage Treated. | Tons Solids per Million Gallons Sewage Treated. Ton, 2 000 Lb. |
|---|---|---|---|
| 2 and 3 | 300 000 | 3 610 | 0.95 |
| 4, 5 and 6 | 500 000 | 3 282 | 0.74 |
| 7, 8, 10 and 11 | 750 000 | 1 671 | 0.39 |
| 12 and 13 | 1 000 000 | 1 614 | 0.24 |

A comparison of the quantity of sludge produced by sedimentation and chemical precipitation is interesting. The volume produced by chemical precipitation in the years following 1901 is materially less than that of former years for reasons given in the discussion of that process. It would seem, however, that the most reasonable comparison between the two methods would be during the years 1902 and 1903, because the sedimentation experiments were conducted during that time. With a flow of 300 000 gal. through the basin daily, the volume of crude sewage sludge amounted to 75 per cent. of the sludge produced by the lime treatment. At a flow of 1 000 000 gal. per day, however, this ratio was reduced to 33 per cent., with the obvious result that a correspondingly greater amount of suspended matter was carried out of the settling tank to the filter beds.

It is important to take into consideration the fact that the flow through the chemical precipitation basins amounted to about 1 000 000 gal. per basin per day.

It is noticeable that the ratio of the weights of solid matter in the sludge produced by sedimentation to that of chemical precipitation is somewhat smaller than the ratio of the volumes produced, the former ranging from 15 per cent. at the high rates to 65 per cent. at the low rates.

There are several things which have perhaps a greater influence upon the weight of solid matter produced than upon the volume of the sludge. Among these are the admission of storm sewage, the addition of lime and the more complete precipitation of iron salts and ordinary suspended matter of the sewage in the case of chemical precipitation.

The sludge from sedimentation resembles that from chemical precipitation in most respects. It is, perhaps, somewhat darker in color, due to the presence of a greater proportion of sulphide of iron. The absence of lime and the flocculent precipitate of ferrous hydrate is quite noticeable. The odors are similar, which fact would tend to show that the crude sewage sludge had not become thoroughly septic.

This sludge was conveniently disposed of by filter pressing. The cost was about one third in excess of the cost of pressing a corresponding volume of sludge from chemical precipitation, due largely to the increased amount of lime required. The amount of lime used was about 100 lb. per 1 000 gal. pressed.

The fact that sludge partitions were placed in the sedimentation basin made it possible to compare the quantity and quality of the sludge deposited in the four sections, the data for which are presented in Table VI.

The depth of sludge deposited at the different rates of flow were nearly the same, averaging from 8 to 9 in. at all rates. As would naturally follow, the distribution varied with the flow, the greater the velocity the further the sludge was carried; so that with the smallest flow the depth in the first section was greatest, and least in the fourth section.

It is interesting to note that the ratio of volatile matter to the total residue on evaporation, about 2:3, was nearly uniform in all sections and at all rates.

In comparing the amount of nitrogenous organic matter, it will be noticed that the proportion of organic nitrogen decreases from section to section. On the other hand, it increases in all the sections with the velocity. The large proportion of nitrogen in the first section at the 1 000 000 gal. rate may perhaps be accounted for by the separation of the coarser matter, which formed scum, from the finer particles which made up the sludge.

# TABLE VI.

## A Comparison of the Sludge Deposited in the Different Sections of the Sedimentation Basin at Different Rates of Flow.

| Flow through Basin. | Residue on Evaporation. (Per Cent.) Total. Sections. 1 | 2 | 3 | 4 | Volatile. Sections. 1 | 2 | 3 | 4 | Fixed. Sections. 1 | 2 | 3 | 4 | Proportion of Volatile to Total Residue (Per Cent.). Sections. 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 500 000 gal. | 5.93 | 5.72 | 3.98 | 2.50 | 3.71 | 3.62 | 2.88 | 1.54 | 2.22 | 2.10 | 1.10 | 0.96 | 62.56 | 63.28 | 72.36 | 61.60 |
| 750 000 ,, | 5.84 | 4.86 | 3.35 | 2.85 | 3.69 | 3.13 | 2.18 | 1.79 | 2.15 | 1.74 | 1.17 | 1.06 | 63.19 | 65.64 | 65.09 | 62.82 |
| 1 000 000 ,, | 4.90 | 3.52 | 2.83 | 2.40 | 3.11 | 2.28 | 1.89 | 1.58 | 1.79 | 1.24 | 0.94 | 0.82 | 63.48 | 64.77 | 66.79 | 65.85 |

| Flow through Basin. | Organic Nitrogen in Wet Sludge (Per Cent.). Sections. 1 | 2 | 3 | 4 | Organic Nitrogen in Dried Sludge (Calculated) (Per Cent.). Sections. 1 | 2 | 3 | 4 | Depth of Sludge (Inches). Sections. 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 500 000 gal. | .214 | .194 | .067 | .047 | 3.61 | 3.39 | 1.68 | 1.88 | 17 | 8 | 5 | 3 |
| 750 000 ,, | .280 | .259 | .178 | .133 | 4.80 | 5.33 | 5.31 | 4.66 | 16 | 10 | 7 | 4 |
| 1 000 000 ,, | .667 | .338 | .160 | .212 | 13.61 | 9.60 | 5.65 | 8.81 | 15 | 9 | 5 | 6 |

In this case the scum over section 1 was 12 in. thick, while in the periods run at lower rates there was much less scum formed. This coarser matter consisted largely of paper, cloth and grease, in which the nitrogen was comparatively low, and when this matter was separated from the sludge the nitrogen content of the latter was proportionally increased.

### Sludge and Scum Resulting from Septic Treatment.

The following experiments with the septic treatment of sewage were started in July, 1901, and continued until July, 1903. The first experiment began July 8, 1901, and was terminated March 1, 1902, when the tank was entirely cleaned out. The second series of experiments began May 22, 1902, and was terminated July 2, 1903. The settling basin used for these studies has already been described under the subject of sedimentation, except that during the first experiment there were no sludge partitions nor scum boards in the basin. The principal points of importance are given in Table VII.

TABLE VII. Statistics Regarding the Sludge Produced by the Septic Tank.

| | Experiment No. 1. July 8, 1901, to March 1, 1902. Gallons. | Experiment No. 2. May 22, 1902, to July 2, 1903. Gallons. |
|---|---|---|
| Contents of basin | 350 000 | 350 000 |
| Rate of flow through basin | 300 000 to 500 000 | 300 000 to 750 000 |
| Total flow for period | 99 790 000 | 185 000 000 |
| Sludge remaining at end of period | 79 000 | 56 250 |
| Sludge remaining at end of period, per million gallons sewage | 792 | 304 |
| Relation of volume of sludge to sewage | 0.079 per cent. | 0.030 per cent. |
| Solids in sludge | 4.40 per cent. | 14% { 5.55% sludge, 28.84% scum |
| Solids in sludge per million gallons sewage | 0.145 tons | 0.177 tons |

The results of these two experiments were in general quite similar. The most notable difference between them was that in the first experiment there was practically no scum formed. There was occasionally a small amount of floating matter on the surface of the basin, but this was frequently disturbed by wind or rain and driven to the bottom of the tank. There was nothing which could be called permanent scum.

It is also important to note that the sludge formed during the second experiment was denser than that formed during the first, and when the scum is added this difference becomes very material. The amount of solid matter in the sludge at the end of the second experiment was greater per million gallons sewage than at the end of the first. These variations are, however, probably due to the fact that during the second run the settling basin was provided with sludge partitions and scum boards.

When sewage is first turned into the septic tank a considerable proportion of the suspended matter settles to the bottom. The bacterial life is greatly intensified in the sludge, as shown by the number of bacteria found, the sludge frequently containing as many as 12 000 000 bacteria per cu. cm., while the effluent from the tank rarely contained more than 1 000 000. The action of the germs on the organic matter of the sludge produces large quantities of gas. This gas is held mechanically by the solid matter until it is collected in sufficient quantity to lift large amounts of the sludge. At such times there is a violent ebullition, which carries a great deal of suspended matter from the bottom to the top of the tank.

Sewage contains a very considerable amount of fats. Determinations made at the time of these experiments disclosed as much as 9.58 per cent. by weight in the dry residue on evaporation.

Soon after the septic tank is put into operation, if the weather is warm, a thin film of oil is noticeable on the surface of the water. The sludge which is brought to the top of the basin by the gases entangled in it is surrounded with a film of grease, which assists in retaining it at the surface. The film of oil also prevents the free liberation of the gas from the water, so that there soon forms a thin coating of sludge and grease containing much gas which has been liberated from the sludge. If a severe wind storm or rain should take place under these conditions this thin film of scum would be broken up, the gas liberated and the solid matter driven to the bottom of the basin, and this may account for the frequent failure, under certain conditions, of the septic process to produce scum.

During cold weather the grease upon the surface is congealed, so that there is no film of oil on the surface to assist in the formation of a scum.

If the light scum described is undisturbed by the elements, frequent additions of gas and solids cause it to become thicker from time to time, until it acquires sufficient stability and

tenacity to act as a mass. In this condition it contains a very large quantity of gas, which makes the crust acting as a unit much lighter than water; hence it floats, like a rubber sponge, on the surface of the sewage, the upper portion rising considerably, often 6 in. above the water. As the mass gradually rises, the surface is dried by the action of the sun and wind, and becomes tough and strong, a condition not as likely to obtain in a covered tank. With the formation of the tough surface, birds and small animals can walk upon it, and after the scum has acquired a considerable thickness a man can stand with safety upon it, as illustrated by the accompanying photograph.

An effort was made, after the scum had attained a thickness of at least 12 in., to disengage the gas from it, so that it might settle to the bottom of the basin. This effort, however, was unsuccessful, as there was such a large quantity of gas that all of it could not be disengaged, and the liberation of gas from the sludge was so rapid that that which was expelled from the scum was immediately replaced by a fresh supply from below. Table VIII gives some interesting statistics regarding the thin and thick scum and the sludge.

TABLE VIII. Composition of the Sludge and Scum of the Septic Tank.

| | Fats in Dry Sample. Per Cent. | Fats in Wet Sample. Per Cent. | Organic Nitrogen. Per Cent. | | Total Solids. Per Cent. | Volatile Solids. Per Cent. | Fixed Solids. Per Cent. | Specific Gravity. |
|---|---|---|---|---|---|---|---|---|
| | | | Wet Sample. | Dried Sample. | | | | |
| Thin scum... | 11.83 | 0.81 | .280 | 4.076 | 6.87 | 3.79 | 3.08 | 1.021 |
| Thick scum. | 10.24 | 2.95 | .909 | 3.152 | 28.84 | 15.30 | 13.54 | 1.062 |
| Sludge.... . | 5.83 | 0.32 | .273 | 4.919 | 5.55 | 2.35 | 3.20 | 1.040 |

Specific gravity determined by weighing measured volume of liquid scum or sludge. Gas was completely expelled by stirring.

The sludge from the septic tank was black in color, very finely divided, slimy and always of an extremely offensive odor. The scum, however, served a useful purpose in the basin by preventing the escape of the offensive odors into the surrounding air, and by protecting the sewage from severely cold weather. Both the sludge and the scum varied from time to time in amount, and it was somewhat difficult to explain just the reason for this.

Sludge decomposes more rapidly during warm weather,

Scum on Septic Tank. The Men are Standing on the Scum.

and consequently there was a general tendency to form a thicker crust at such times, and, conversely, during the winter season the sludge tended to increase in quantity. There were frequent changes in the depth of scum and sludge, apparently coinciding with each other, which indicated that at times a large body of sludge was carried up and formed a part of the crust, and later gases were liberated, so that corresponding amounts of scum were deposited, increasing the amount of sludge. These changes were, however, difficult to study, and no other explanation could be given than the entangling of the gases, and later the liberating of the same.

The action of the gases seemed to separate the sludge into classes, the coarse material, such as paper and cloth, being carried to and retained in the scum, the resulting sludge consisting of very finely divided matter. This separation was also affected by both the sludge partitions and the scum boards.

It is suggested, by the several conditions existing in these two experiments, that the presence of a large quantity of coarse particles may be an important factor in the formation of a permanent and increasing scum.

The absence of the grosser matters in well-screened sewage may account for the non-appearance of scum in some septic tanks. It was observed that in the sludge resulting from the first experiment there was very little coarse material, probably due to disintegration by septic action. In the second experiment, however, the coarse matters in the scum did not appear to have been acted upon to any great extent. These two facts would tend to show that the septic action is very largely confined to the sludge.

At the close of the second experiment the crust in the first section was 18 in. deep and very coarse; in the second section it was barely 6 in. deep and comparatively fine; while in the third and fourth sections there was a mere film of oil with a small amount of solid matter with it. This shows that the scum board retained the grosser solids in the first section.

Table IX is a statement of the solids found in the sludge and scum of the different sections of the basin. The solids in the scum of the second section, however, are calculated from the analyses of the thin scum, and are undoubtedly less in quantity than actually existed.

It is interesting to note the decrease in the proportion of volatile matter to total solids from the first section where the sewage entered the basin to the fourth section from which it

TABLE IX. Solids in Sludge in the Different Sections of the Septic Tank.

(Per Cent.)

| No. of Section. | Depth of Sludge. Inches. | | Total Solids. | Volatile Solids. | Fixed Solids. | Relation of Volatile to Total Solids. |
|---|---|---|---|---|---|---|
| | Scum | Sludge. | (Inc. Scum) | (Inc. Scum) | (Inc. Scum) | (Inc. Scum) |
| 1 | 18 | 6 | 2.58 (22.28) | 1.30 (11.80) | 1.28 (10.48) | 50.38 (52.97) |
| 2 | 6 | 10 | 4.95 (5.53) | 2.30 (2.75) | 2.65 (2.78) | 46.46 (49.73) |
| 3 | Film | 9 | 6.62 .... | 2.81 .... | 3.81 .... | 42.42 .... |
| 4 | Film | 12 | 6.86 .... | 2.62 .... | 4.24 .... | 38.19 .... |

| Number of Section. | Organic Nitrogen in Wet Sludge. | | Organic Nitrogen in Dried Sludge. | |
|---|---|---|---|---|
| | | (Inc. Scum) | | (Inc. Scum) |
| 1 | 0.037 | (0.691) | 1.43 | (3.10) |
| 1 | 0.144 | (0.265) | 2.91 | (4.79) |
| 2 | 0.370 | .... | 5.59 | .... |
| 3 | 0.290 | .... | 4.23 | .... |

was discharged. Considering the sludge alone, however, the organic nitrogen increases from section to section.

There was more nitrogen in the scum of the first two sections than there was in the corresponding sludge. Combining sludge and scum of these sections, the amount of nitrogen was found to be fairly uniformly distributed throughout the four compartments of the basin.

The distribution and amount of nitrogen were quite different from that found in the experiments upon sedimentation. There was more nitrogen present than when the sedimentation tank was run at the 500 000 gal. rates, and considerably less than at the rate of 1 000 000 gal.

The greatest proportion of nitrogen was found in the second and third section, which was also true with the 750 000 gal. rate in the sedimentation tank, while at the 500 000 gal. and 1 000 000 gal. rates the first and second sections contained sludge which was much richer in nitrogen.

Septic action was so vigorous in the first section of the septic tank that large quantities of gas were evolved. This gas contained a substantial amount of nitrogen, which fact

undoubtedly accounts in part for the smaller proportion of nitrogen found in the sludge and scum of this compartment. It is possible also that the increase in free ammonia in the effluent may offer another explanation of this condition.

The province of the septic tank is to control and, in part at least, to destroy and dissolve some of the suspended substances in sewage so that subsequent processes of oxidation may not be impeded by them.

The extent to which this purpose is realized and the efficiency as compared with chemical precipitation, sedimentation or no preliminary treatment at all, is shown by the following tabulation of the volume of sludge and weight of solid matter in the sludge and effluent.

VOLUME OF SLUDGE PRODUCED BY CHEMICAL PRECIPITATION, SEDIMENTATION AND SEPTIC TANK.

(GALLONS PER 1 000 000 SEWAGE.)

| | |
|---|---|
| Chemical precipitation (average 1902 and 1903)...... | 4 872 |
| Sedimentation (average at all rates)................ | 2 544 |
| Septic tank (average of two experiments)........... | 548 |

SUSPENDED SOLIDS IN EFFLUENT AND SLUDGE FROM CHEMICAL PRECIPITATION, SEDIMENTATION AND SEPTIC TANK.

(TONS [2 000 LB.] DRY SOLID MATTER PER 1 000 000 GALLONS SEWAGE.)

| | Effluent. | * Sludge. | Total. |
|---|---|---|---|
| Sewage (from outfall sewer: average 1902 and 1903)........................... | 1.247 | .... | 1.247 |
| Chemical precipitation (average 1902 and 1903)............................... | 0.250 | 1.435 | 1.735 |
| Sedimentation (average at all rates)....... | 0.601 | 0.580 | 1.181 |
| Septic tank (average of two experiments) | 0.840 | 0.161 | 1.001 |

* Including scum.

The volume of sludge produced by chemical precipitation may be varied greatly by manipulation affecting its density. It would probably be impracticable, however, under existing conditions in Worcester, to reduce the volume materially below that here given. This amount, however, is the largest appearing in the table.

Sludge from sedimentation comes next in quantity, being about 52.2 per cent. of the volume produced by chemical precipitation. As the only difference between sedimentation and the

septic process lies in the fact that the sludge is removed from the sedimentation tank at frequent intervals, it is apparent that the amount of sludge can be varied at will until it reaches a volume corresponding to that produced by the septic tank. In these experiments an effort was made to remove it before the fermentation had become very active.

Less sludge is produced by the septic tank than by either of the other methods. In these experiments it amounted to 11.2 per cent. of that produced by chemical precipitation during 1902 and 1903.

The weight of suspended solids in the sludge and effluent from chemical precipitation is found to be materially in excess of the amount present in the crude sewage. This is due to the addition of lime, a large portion of which remains undissolved, and the precipitation of hydrate of iron. In the sewage the iron compounds are largely in solution, so that their precipitation transforms them from soluble to insoluble matter.

The suspended matter accounted for in the sedimentation process is remarkable, being within about 5 per cent. of that in the original sewage — probably within the limits of error in measuring and sampling.

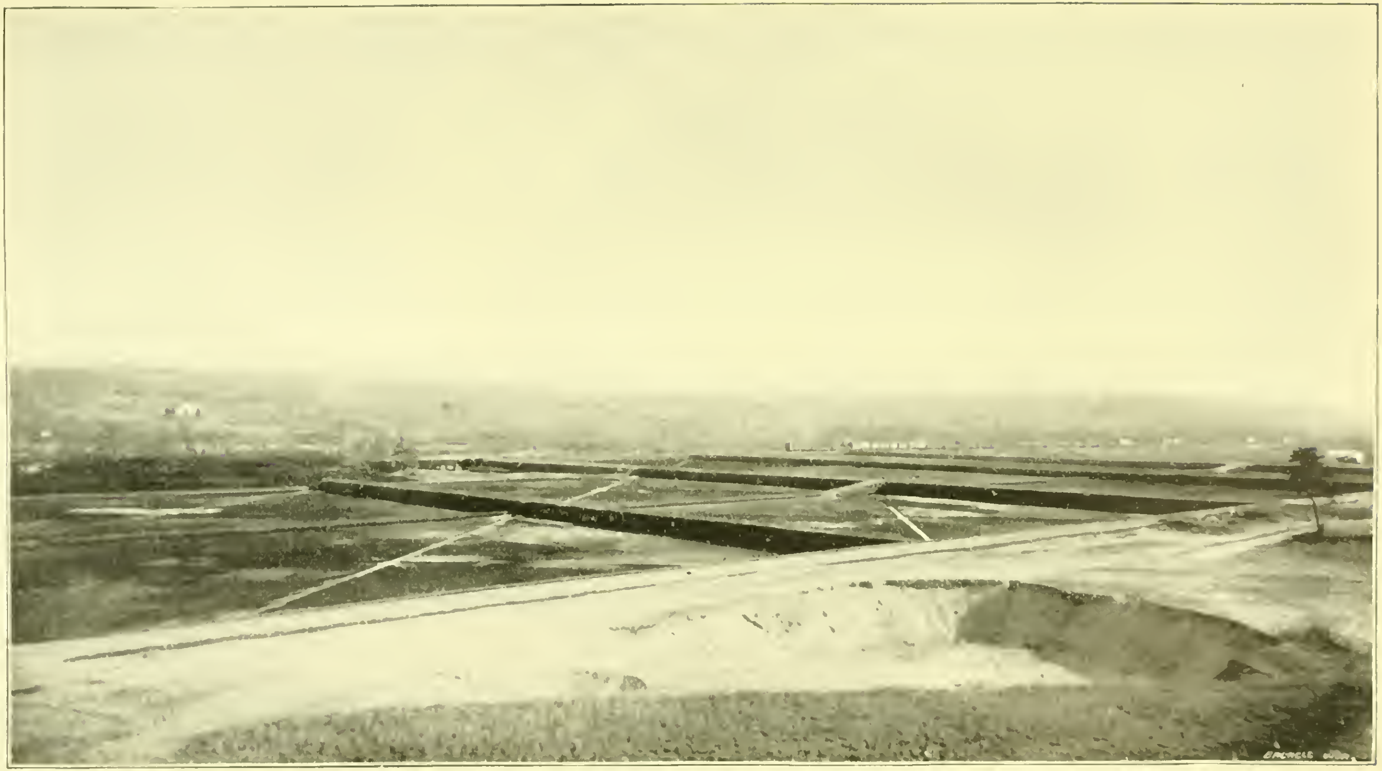
The septic process shows the lowest weight of solid suspended matter, as it did the smallest volume of sludge. The reduction as compared with crude sewage amounts to about 20 per cent.

In considering this reduction, the fact should be borne in mind that much of the soluble iron of the sewage is precipitated in the septic tank, thereby increasing the suspended matter above that originally in the sewage. It would appear, therefore, that the actual reduction of organic matter must have been in excess of 20 per cent. by an amount equivalent to the weight of iron sulphide precipitated.

## Suspended Solids in the Effluent from Chemical Precipitation and the Effect of the Same upon Intermittent Filtration.

The amount of suspended solids in the effluent from chemical precipitation varies from a trace under the best conditions to about 10 parts per 100 000, or 833 lb. per 1 000 000 gal. Of this amount, roughly, one half is organic and volatile.

It has been the custom in the filtration of chemical effluent to apply that of poorest quality to the beds, and although no



Filter Beds, Worcester, Mass.

Removing Clogging Material from Filter which has Received Effluent from Chemical Treatment, Worcester, Mass.

complete record has been kept of the suspended solids in the water applied, it may be estimated from various determinations to be about 500 lb. per 1 000 000 gal.

This suspended matter is in a finely divided condition and readily penetrates the sand to a depth of nearly 2 in. As this process continues the pores of the sand gradually fill with sludge, and on application of the effluent the mass quickly becomes saturated with water, retards the progress of filtration and dries out very slowly, the sand below this stratum draining rapidly. The gradual change in the nature of the surface layer decreases the capacity of the filter, until it becomes imperative to remove the material causing surface clogging.

It has been found, however, that in winter freezing makes this stratum more porous, so that a larger quantity of water will pass through it than during warmer weather. This fact is well illustrated by the record of water filtered through one bed, as follows:

| | Gallons. |
|---|---|
| June, 1903 | 1 473 000 (two days) |
| July, 1903 | 10 943 000 |
| August, 1903 | 9 110 000 |
| September, 1903 | 4 963 000 |
| October, 1903 | 3 154 000 |
| November, 1903 | 1 895 000 |
| December, 1903 | 4 026 000 |
| January, 1904 | 5 944 000 |
| February, 1904 | 6 248 000 |
| March, 1904 | 5 926 000 |
| April, 1904 | 2 470 000 |
| May, 1904 | 2 922 000 |

This record was made by one of four 1-acre filter beds, which were thoroughly scraped to a depth of about 4 in. in June, 1903, and the effluent from chemical precipitation applied for one year. At the end of this time about 1.5 in. of poor material had accumulated on the surface of the beds, and they were working very slowly. Temporary relief could have been obtained by harrowing, but experience has shown that it is not wise to mix the poor material with the clean sand.

On two previous occasions about one quarter (in depth) of the clogged sand had been removed from some beds, others being allowed to rest a few weeks during the cleaning. It was found that the partial removal accomplished little more than resting. Accordingly, in June, 1904, practically all of the poor material was removed. The dividing line between the poor

material and the comparatively clean sand was fairly well defined.

The total amount of chemical effluent applied per acre to the 4 beds for the period of 336 days was 58.44 million gal., or at an average rate of 174 000 gallons per acre daily.

The material removed from these 4 beds in June, 1904, amounted to 1.4 in. in depth and measured 208 cu. yd. in the cars as hauled away. This amount is equivalent to 3.56 cu. yd. per 1 000 000 gal. of chemical effluent filtered during the period.

The cost of cleaning these beds and removing the waste material was \$95.03 per acre, or \$0.45¾ per cu. yd., equivalent to \$1.62½ per 1 000 000 gal. filtered.

The material removed from the filters was analyzed with the following results:

| | Per Cent. |
|---|---|
| Moisture | 13.92 |
| (Sample dried at 110 degrees cent.) | |
| Ferric oxide | 3.48 |
| Calcium oxide | 1.00 |
| Organic nitrogen | 0.263 |
| Sand | 85.00 |
| Organic matter (by ignition) | 5.58 |

At times sufficient lime was precipitated on the surface of the filter to form a hard crust which impeded the passage of water. This crust was very thin, not exceeding one quarter of an inch in thickness. It was broken up by scratching with a horse wire-tooth weeder, after which the water penetrated the sand without difficulty from this source.

## Suspended Solids in the Effluent from Plain Sedimentation and the Effect of the Same upon Intermittent Filtration.

The amount of suspended solids in the effluent from plain sedimentation depends upon the strength of the sewage, and consequently upon the rainfall and season of the year, as well as upon the rate of flow through the basin. This fact should be borne in mind in the examination of Table X. The amount is much in excess of the suspended solids in the effluent from chemical precipitation, but considerably less than in the septic effluent. This subject is further treated in connection with the discussion of the suspended solids in the effluent from the septic tank.

The action of the suspended solids in the effluent from plain sedimentation in clogging the surface of filters is similar

to that previously described in connection with the filtration of chemical effluent, except that a greater proportion remains on the surface. It is, however, impossible to remove this without removing at the same time a large amount of sand. This cleaning does not remove the foreign matter entirely, as a portion of it has penetrated the filter to a depth of from 1 to 2 in. and in time it will be necessary to remove this portion also.

The only explanation of the difference in the effect on the filters of the suspended matter from the various processes of preliminary treatment seems to lie in the physical condition of that matter. It is very noticeable that in the effluent from sedimentation the solids, although finely divided, are of a somewhat fibrous nature. The fibers interweave and form a sort of mat or fabric. As soon as this begins to build it retains a large proportion of the fine material, some of which is granular, and would penetrate the filter were it not retained on the fibrous film. More fiber builds on to the mat with each application of settled sewage until the accumulation becomes so thick that it will not allow the water to pass readily through it. It is then found that, after drying, this surface layer can be raked off without taking as large a proportion of sand as when the surface of a bed which has received chemical effluent is scraped.

In a well-settled sewage, however, there is not enough fiber to prevent the fine material from entering the pores of the filter to such an extent that the upper layer of sand must be taken off at intervals.

TABLE X. SUSPENDED SOLIDS IN THE EFFLUENT FROM SEDIMENTATION.

| Date of Period. | Nominal Rate per Day for Period in Gallons. | Suspended Solids in Pounds per Million Gallons. | | |
|---|---|---|---|---|
| | | Total. | Volatile. | Fixed. |
| April 5 to May 5, 1902 ...... | 300 000 | 916 | 233 | 683 |
| May 23 to June 28, 1902 . . . | 300 000 | 1 525 | 858 | 667 |
| July 9 to Aug. 2, 1902 ...... | ½ at 300 000<br>½ at 400 000 | 1 191 | 616 | 575 |
| Aug. 3 to Sept. 1, 1902 ...... | 400 000 | 1 417 | 575 | 842 |
| Sept. 6 to Oct. 7, 1902 ...... | 500 000 | 1 775 | 617 | 1 158 |
| Oct. 8 to Nov. 1, 1902 ...... | 600 000 | 1 333 | 800 | 533 |
| Dec. 21, 1902, to Feb. 7, 1903, | 750 000 | 692 | 275 | 417 |
| Feb. 8 to March 20, 1903 .... | 750 000 | 1 191 | 558 | 633 |
| March 21 to May 1, 1903 ..... | 750 000 | 841 | 433 | 408 |
| May 3 to May 31, 1903 ...... | 750 000 | 1 016 | 608 | 408 |
| June 6 to July 2, 1903 ....... | 750 000 | 1 042 | 567 | 475 |
| Aug. 17 to Sept. 12, 1903 .... | 1 000 000 | 1 616 | 933 | 683 |
| Sept. 16 to Oct. 14, 1903 ..... | 1 000 000 | 1 358 | 625 | 733 |

With crude, unsettled sewage there will be formed a much heavier coating upon the surface of the filter, and this will doubtless retain much more of the fine particles, so that it will be necessary to remove the upper portion of the sand only at comparatively long intervals.

## Suspended Solids in Sewage and the Effect of the Same upon Intermittent Filtration.

During the year 1905, crude sewage direct from grit chambers was filtered upon several sand beds. The filters were flowed only during the day, and therefore the sewage was much stronger than the average of that received during the 24 hr. The amount of suspended matter in this sewage ranged from 2 000 lb. to 4 000 lb. per million gal., averaging for the year 3 500 lb., of which about two thirds was organic and volatile. The amount filtered per acre per day averaged 91 000 gal.

It was noticeable that the suspended matter in the sewage passing from the grit chambers was much coarser than that in the effluent from the sedimentation tank.

The coarse and fibrous material is retained on the surface of the sand, forming a woven mat. As soon as this mat begins to form, which is as soon as the first dose is applied, it retains the suspended matter in the sewage subsequently turned on to the filter. In this way the mat continually increases in thickness.

After the water has passed through, this material dries, weather conditions permitting, shrinks, cracks and usually curls, separating from the sand. While the suspended matter undoubtedly reaches the sand to a limited extent through the cracks in the mat, in the main the mat forms a very complete protection.

The large quantity of suspended matter in the unsettled sewage makes it necessary to clean the beds more frequently than in the case of settled sewage. It has been found necessary to rake over portions of the beds at least as often as once in 2 weeks. This material is generally raked up into piles and removed from the beds only after it has accumulated to quite an extent. Great care is taken to prevent the mixing of any of this material with the sand, and it is interesting to note how clean and soft the sand immediately under the mat remains.

The clogging material on these beds has been removed under several different conditions. When the thermometer registers about 32 degrees fahr., this material freezes in the form of a crust

Mat Formed on Filter which has Received Crude Unsettled Sewage, Worcester, Mass.

Surface of Filter which has Received Crude Unsettled Sewage, Worcester, Mass.

and can be taken off with very little labor. When taken off in this way considerable sand adheres to the bottom of the crust and is removed from the filter. If the weather is extremely cold, it is impracticable to remove the crust, as it comes off in thick pieces, sometimes 2 or 3 in. in thickness, all but the upper quarter of an inch being clean sand.

The quantity of refuse removed from the surface of these filters has amounted to about 14 cu. yd. per million gal. of sewage treated, and the cost of removing the same averaged $0.49 per cu. yd.

The two views illustrate clearly the description just given. The strength and size of the mat of fibrous material is well illustrated by the large piece which is being held up by the four men, and the other illustrates how this mat can be rolled up and taken off without disturbing the underlying sand.

The following analysis of this leather-like substance is interesting:

| | Per Cent. |
|---|---|
| Moisture | 6.13 |
| Loss on ignition | 51.45 |
| Organic nitrogen | 2.31 |

It is very noticeable that the coarsest material settles nearest to the distributor; therefore, as would be expected, less sand is removed from this portion of the bed at each cleaning than from the center of the bed. This is well illustrated by the analyses given in the following table.

Analyses of Refuse Material Removed from Beds 19 and 23, Near and Remote from Distributors.

| | Bed 19. | | Bed 23. | |
|---|---|---|---|---|
| | Near Distributor. | Remote from Distributor. | Near Distributor. | Remote from Distributor. |
| | Per Cent. | Per Cent. | Per Cent. | Per Cent. |
| Moisture | 14.44 | 12.53 | 28.0 | 1.10 |
| Dry solids | 85.56 | 87.47 | 72.0 | 98.90 |
| | | Dried at 110° cent. | | |
| Loss on ignition | 11.29 | 6.76 | 16.16 | 9.87 |
| Fixed solids | 88.71 | 93.24 | 83.84 | 90.13 |
| *Insoluble fixed solids | 72.86 | 87.55 | 76.71 | 85.32 |
| Ferric oxide | (Not determined) | | 0.027 | 0.023 |
| Organic nitrogen | 0.520 | 0.377 | 0.918 | 0.827 |
| Weight per cu. ft. | 63.26 lb. | 81.85 lb. | 70.69 lb. | 82.36 lb. |
| Specific gravity (of mass) | 1.001 | 1.31 | 1.13 | 1 318 |

* This determination approximates the amount of sand removed from the filter; but includes, of course, that portion of the fixed suspended matter of the sewage which is insoluble in hydrochloric acid.

The difference between the analyses given in this table and that immediately preceding is due to the fact that the latter analyses are of the average of the material removed, which is quite different from the leather-like mat which is represented by the first set of analyses.

## Suspended Solids in the Effluent from the Septic Tank and the Effect of the Same upon Intermittent Filtration.

The septic tank received sewage continuously from May 23, 1902, until July 2, 1903, except when storm water was running, and except from November 1 to December 21, 1902, when the basin was shut down on account of the construction of a new effluent channel. The basin was next to another tank of exactly the same dimensions, and which was used for sedimentation. To assure uniform conditions in the two tanks, they were operated at the same rates during the same periods of time. The duration of each period was fixed by the conditions existing in the sedimentation tank, which was shut off before marked septic action was apparent. To make the results of the septic treatment and sedimentation strictly comparable, the samples from the septic tank were taken through periods which corresponded with those of the settling basin.

From the results given in Table XI, it is difficult to trace any very decided condition to the rate of flow through the basin. It was believed, however, from the practical working of

TABLE XI. Suspended Solids in the Effluent from the Septic Tank.

| Period. | Nominal Rate of Flow per Day. | Suspended Solids in Pounds per Million Gallons. | | |
|---|---|---|---|---|
| | | Total. | Volatile. | Fixed. |
| May 23 to June 28, 1902 .... | 300 000 | 1 708 | 1 008 | 700 |
| July 9 to Aug. 2, 1902 ....... | ½ at 300 000<br>½ at 400 000 | 1 300 | 442 | 858 |
| Aug. 3 to Sept. 1, 1902 ...... | 400 000 | 1 734 | 775 | 959 |
| Sept. 6 to Oct. 7, 1902 ...... | 500 000 | 2 816 | 1 275 | 1 541 |
| Oct. 8 to Nov. 1, 1902 ...... | 600 000 | 1 942 | 1 000 | 942 |
| Dec. 21, 1902, to Feb. 7, 1903, | 750 000 | 922 | 367 | 555 |
| Feb. 8 to March 20, 1903 .... | 750 000 | 1 650 | 817 | 833 |
| March 21 to May 1, 1903 .... | 750 000 | 1 291 | 683 | 608 |
| May 3 to May 31, 1903 ...... | 750 000 | 1 700 | 1 058 | 642 |
| June 6 to July 2, 1903 ...... | 750 000 | 1 734 | 1 116 | 618 |
| Average .............. ............... | | 1 680 | 854 | 826 |
| Average of sedimentation for same period.. | | 1 202 | 591 | 611 |

Leveling Bed after Removing Deposit.

the tank and filter beds which received the septic effluent, that 750 000 gal. was as high a rate as could be passed through the basin without carrying out an unreasonable amount of suspended matter.

There is a noticeable difference in the amount of solid matter carried out of the basin between the warm and cold periods. The 750 000 gal. rate for 5 periods produced less suspended matter in the effluent than was present in several warm periods at much lower rates of flow. It is quite probable, however, that the small amount of suspended matter in the first 750 000 gal. period was due to the fact that the tank was shut off and standing full for about 6 weeks immediately preceding this period.

The high solids during the September period were apparently due to the very active condition of the tank, which condition has been found to be usual during the months of August and September. These two months have always constituted a period of very active fermentation in the chemical sludge as well as in the septic sludge.

The most important fact disclosed in a comparison of the suspended solids in the effluents from septic treatment and sedimentation is that they were, in every period, higher in the effluent from the septic tank. This was doubtless due to the active fermentation going on in the septic tank, which condition was not allowed to exist in the sedimentation basin. Even the 1 000 000 gal. rate during August and September in the sedimentation basin was productive of lower suspended solids in the effluent than the average of all the periods of the septic tank.

The suspended solids in the septic effluent from July 8, 1901, to March 1, 1902, averaged about 100 lb. per 1 000 000 gal. higher than the average during the second experiment. This was undoubtedly due to the scum boards and sludge partitions which were not constructed until after the conclusion of the first experiment.

The suspended matter in the effluent was very finely divided, and contained considerable sulphide of iron. When applied to filters, the solids penetrated the sand and clogged the pores much as do the solids in the chemical effluent. There was not a great difference between the results of filtering the effluents from septic treatment and sedimentation. The odor from the filter receiving septic effluent was very much more offensive than that from the filter receiving settled sewage.

## Summary of Conclusions.

In drawing conclusions from the foregoing description of various methods of sewage treatment, due consideration should always be given to the fact that the sewage of Worcester contains large quantities of manufactural wastes, the most important being that from the foundries and wire mills, consisting largely of sulphate of iron.

Following are a few of the conclusions which might reasonably be drawn from the facts already presented:

### *Chemical Precipitation — Sludge.*

1. Sludge from chemical precipitation is more voluminous and of greater net weight than that from sedimentation or the septic tank.

2. Where waste pickling liquids from foundries and wire mills are discharged into the sewers, a large volume of sludge is produced by the addition of lime, thus precipitating the iron.

3. If storm water is admitted to the sewers large quantities of road detritus will be deposited in settling basins or grit chambers, and the proportion of mineral to organic matter will be correspondingly increased.

4. Sludge from chemical precipitation decomposes with the evolution of gas in much the same way as in the case of the septic tank.

### *Sludge Pressing.*

5. Sludge is most expeditiously pressed when it has reached a density of from 4 to 7 per cent. solids and is comparatively fresh.

6. Fresh sludge requires from 20 to 30 lb. of lime per 1 000 gal. to assure economical pressing, and if decomposition has made considerable progress, as much as 100 lb. may be needed.

7. Septic tank sludge containing large quantities of sulphide of iron is extremely difficult to press.

8. Sludge removed in a fairly fresh state from the sedimentation basin is readily pressed with 100 lb. of lime per 1 000 gal.

### *Sedimentation — Sludge.*

9. The volume and the weight of solids of sludge vary inversely with the flow through the settling basin.

10. The quantity (both by volume and by weight of solids) of sludge produced is always less than that resulting from chemical precipitation.

*Septic Tank — Sludge.*

11. The sludge always had a very offensive odor, possibly due to sulphur compounds, although hydrogen sulphide was never found to be present in the gas evolved from the tank.

12. Septic action was far more vigorous in the sludge than in the scum, there being comparatively little disintegration of the latter.

13. If the formation of scum can be prevented, there will be a disintegration of the coarser particles at least into finer matter.

*Suspended Matter in Effluent from Chemical Precipitation.*

14. Enough suspended matter passes out of settling basins with effluent to cause clogging of sand filters.

15. This material must be removed from surface of filters at intervals, but as it is finely divided it is impossible to scrape it off without taking also a very large proportion of sand.

16. Lime in effluent (in suspension and solution) is precipitated on and near surface of sand, forming a hard but thin crust, causing clogging.

This crust may be easily broken up by mechanical means.

*Suspended Matter in Effluent from Sedimentation.*

17. Two or three times as much solid matter escapes with the effluent as in the case of chemical precipitation.

18. Some of the solid particles appear to be of a fibrous nature and gradually form a fabric on the surface of the filter.

19. If the sedimentation process is efficient, the suspended matter will be so fine that it will penetrate the sand, soon necessitating its removal to a substantial depth.

*Suspended Solids in Sewage.*

20. The coarse, fibrous substances form a mat on the surface of the filter. This mat is strong and forms a very good protection to the surface of the sand against finely divided particles entering the pores of the sand.

21. The surface of the filter requires frequent cleaning. Clogging material should not be removed when very wet or when frozen to the sand below.

*Suspended Solids in Septic Tank Effluent.*

22. A flow equivalent in 24 hr. to about twice the capacity of the tank is as much as should be run through it unless special

provision is made for settling out the suspended matter before admitting effluent to filter.

23. The amount of suspended matter in the effluent is considerably greater than in that from sedimentation or chemical precipitation.

24. The suspended solids do not necessarily vary in amount directly or indirectly with the flow through the basin, as temperature conditions have a marked effect on account of increasing or decreasing fermentation.

25. The suspended matter was very finely divided and consisted largely of sulphide of iron.

26. The surface of the sand filters became clogged with these substances in a short time.

27. Very offensive odors were given off from filters when flooded and when wet.

## DISCUSSION.

Mr. R. S. Weston. — This paper needs no commendation. It certainly puts the subject in a very clear light.

The relation of the suspended matter in sewage to the problem of sewage disposal is a very important question, especially that phase of it which concerns the physical character of the suspended matter. During the past few years experts have viewed the problem from two entirely different standpoints. At one time it was believed that if the sludge could be precipitated a great gain was effected, while more recently it has been held that if the sludge could be decomposed in a septic tank and thereby lessened in volume, a greater gain was being made; but now it is being learned that the physical character of the suspended matter is fully as important a factor as the apparent amount precipitated and left for subsequent disposal. This is on account of the fact that what really seems to be in solution is not necessarily permanently in solution. For example, it is well known that if one allows a sample of sewage to settle until it is clear, or removes the apparent suspended matter by filtration, some of the organic matter in the clarified sample will subsequently become insoluble and precipitate. In other words, what appears to be soluble precipitates. Matter in this form is called colloidal, and in this state exists neither as true dissolved matter nor suspended matter, but as matter which is in semi-solution. In a septic tank effluent, as Mr. Eddy has shown, there is more of this colloidal or semi-soluble matter than in fresh settled sewage. The experience of the writers of this

paper goes to show that filters receiving sewage clog more rapidly where there are the largest percentages of colloidal matter.

Mr. George A. Carpenter. — *Mr. Chairman and Gentlemen:* I regret very much indeed my inability to put together some of the data which I have gathered in my use of intermittent filtration during the last ten years, and get this information into such shape as would be presentable before this society. I have quite a mass of data, and some of it I have not yet had time to analyze even for my own benefit, let alone the getting of it into shape to present before a meeting like this. I have been much interested in the paper presented and in the review of the advance sheets that were sent to me. I have tried hard to find exceptions to some of the facts stated by Mr. Eddy and Mr. Fales, but have really been unable to do so, for my own experience coincides very uniformly with theirs in respect to the use of the septic tank, the effluent from the same and from sedimentation. I have had no actual experience with chemical precipitation methods. In one respect I am inclined to differ a little from Mr. Eddy, my own experience pointing to the desirability of getting out all of the organic matter as soon as possible before turning the sewage on to the sand filters. I agree with Mr. Eddy that organic matter turned on to the sand will form a mat which will clog the surface and will serve to gather the more finely divided matter, helping to keep it from entering the pores of the sand. That is a satisfactory method in summer, in warm weather, when it will dry out. But my own experience would indicate that the same mat forming in cold weather, clogging the sand and preventing the sewage from getting through, will, under such conditions, render the whole mass liable to become frozen, and will throw the whole bed out of commission. If you attempt to take it off at that time, provided you can, the result is, as Mr. Eddy has stated, that it pulls up two or three inches of sand with it. And so my later practice at Pawtucket has been, through the winter months, to first send the sewage through a small grit chamber, where the flow is greatly reduced, and through a rack, taking out all the suspended matter possible. We have found that we are able to collect in that small grit chamber, on the average, 1 000 lb. of dry solid matter per million gallons of sewage flowing through. It is taken from the chamber in carts and dumped into a hole in the ground, with the result that a large percentage of the water drains away, and the sludge can be covered with sand and the hole filled up. No offense is caused in the winter if this is done.

There are a number of points that I wish I were able to take up and discuss, giving the data that I have gathered in my own experience, but I am not prepared to do so in a proper manner to-night. Recently we have had a troublesome but interesting problem with our filter beds, which have now been running some ten years. The trouble has apparently been caused by a filling of the pores of the sand to a considerable depth with organic matter. This might have been occasioned by an increase in the strength of the sewage, which, in our case, will run about two parts of albuminoid ammonia per 100 000 parts, by a reduction of the time allowed the sewage in passing through the settling tanks, or by forcing of the beds by the application of more sewage than ought to have been applied. I might state, in passing, that the experience in Pawtucket is that it does not seem advisable to dose the beds at an average rate exceeding 50 000 or 60 000 gal. per acre per day, for 365 days in the year. The dose applied, however, is at the rate of 100 000 gal. per acre, and the beds are dosed in rotation, but not every day for 365 days in the year.

Interesting investigations have recently been undertaken to ascertain the amount of organic matter, as indicated by the albuminoid ammonia, which had accumulated in the sand. These showed from 35 to 95 parts per 100 000 albuminoid ammonia in the upper three inches, from 26 to 44 parts per 100 000 in the second three inches, from 12 to 21 parts per 100 000 in the second six inches, from 5 to 9 parts per 100 000 in the second foot, and from 2 to 9 parts per 100 000 in the third foot; while the original sand contained only from 0.5 part to 1.6 parts per 100 000, showing a very serious storage or accumulation of organic matter, especially in the upper layers. The only practical remedy for that condition of things seemed to be the taking off of at least from 6 to 9 in. of the surface of the beds, and that we have been doing. We have replaced the clogged material with 6 in. of new sand, and the result has been that the beds that showed practically no nitrification have rapidly increased in nitrification and now show 2.5 parts of nitrates per 100 000. I have here two or three photographs, taken yesterday, which may be of interest. In one, the drying out of this clogging material and the curling up is very well shown. As I have stated, the origin of the trouble may be due both to the increased strength in the sewage, the limited area of the beds, or to a large percentage of fats in the sewage; any or all of these factors producing conditions favorable to the growth of Oscillaria, which

have been found to be present in large quantities. Mr. Pratt, of the Rhode Island State Board of Health, which is coöperating with us in the study of our filtration work, suggests that I speak of this growth of micro-organisms, which, under the microscope, has been found to be Oscillaria. We have found that, given favorable conditions, this growth spreads very rapidly, and, as indicated by figures I have here, a bed that was cleaned on the 21st of September, after receiving about ten doses of sewage, or a total of 320 000 gal., was in such a condition on the 2d of October that it was left to dry out and will have to be cleaned again. Many of these beds have been in operation since 1894, and have been receiving sewage at the rate before stated. They have been scraped in the fall and in the spring, and have been furrowed during the winter. The furrowing of the beds will undoubtedly cause a mixing of the foreign matter near the surface with the better sand lower down, and this foreign matter will penetrate lower when the furrowing is done with a plow than when it is done by hoeing, but my experience has been that the sewage is better taken care of during the winter season by furrowed beds than it can be by level beds; and I think, notwithstanding the results that we have experienced at Pawtucket, that we shall continue to furrow the beds. We will probably find that it will be cheaper and the results for winter purification better by that method than by any other that I know of; first passing the sewage through the grit chambers, in which the flow is greatly reduced and a large amount of sludge is screened from it, and then through the settling tanks before turning it on to the beds.

One thought arises in my mind regarding the change in the depth of the deposit of sludge in the septic tank and in the thickness of the scum, to which Mr. Eddy referred. My own experience has indicated that that is true, and I have found — and, I think, established without question — that the sludge accumulating in the bottom will suddenly rise and will become scum. And my own thought in that direction, regarding the sampling of the septic effluent and the analysis for the suspended matter in such effluent, questions very seriously whether the results obtained are absolutely correct. I do not know what method may have been pursued in the sampling of such effluent in this instance, but, unless samples are taken continuously, some time that sludge will rise from the bottom, and when it does, in my opinion, a very large amount of suspended matter is going to pass out through the effluent, of which we have obtained no

record. In that respect it is a question, in my mind, whether the results obtained from our analyses do not give more credit to the septic tank than actually belongs to it.

Mr. Weston. — How old is your sewage when it goes on the beds?

Mr. Carpenter. — Our sewage is comparatively fresh. It runs but a short distance in the main sewer, and after passing through the screen chamber remains but a few hours in the settling tanks before being turned on to the beds.

A Member. — Mr. Carpenter spoke of the beds having been overdosed. I should like to ask if it is the feeling that if they had not been overdosed this clogging deep down would not ultimately have occurred.

Mr. Carpenter. — I am inclined to think that there might have been some. I doubt if it would have penetrated as deeply as it has. I think it would have been confined more closely to the upper layers. I think the clogging of the upper layers and continued dosing prevent thorough oxidation of the sewage throughout the bed.

Mr. R. S. Weston. — The speaker has had a case similar to that of which Mr. Carpenter has spoken, where the same phenomena were observed. The bed treated with septic effluent was overdosed; it clogged 5 in. below the surface. The sand was removed to a depth of 6 in. and the bed was restored to its former efficiency. In this case there were about 600 people to the acre, and the beds were dosed from four to five times daily on alternate days. There was a great deal of soapy household waste from a large laundry.

Mr. H. W. Clark. — There is a great deal to be said in regard to the part that the matters in suspension in sewage play in sewage purification. There have been sand filters in operation at the Lawrence Experiment Station for nearly nineteen years. Thirteen years ago some of those filters became so badly clogged near the surface on account of the accumulation of matters strained out from the sewage that this clogged sand, six or eight inches in depth, was removed and new sand placed in the upper portion of several filters in order to maintain them in operation and obtain good effluents. Since then, with rather different care of the filters, they have been operated without any extreme difficulty on account of the accumulation of matter and are now operated at practically the same rate that they have been at any time during the past thirteen years. Two or three years ago, however, these filters again became so clogged as to prevent

quite as good purification as during previous years, although they did not refuse to allow sewage to pass into them easily and at sufficiently high rates. At that time the upper layers contained a great deal of organic matter, fully as much as the beds that Mr. Carpenter has just spoken of. We have tried various methods to get rid of that stored organic matter without removing the sand, but only a small percentage has disappeared in spite of the opportunity given for the upper layers to rest without the application of sewage. It looks now as if it were only a question of time when the upper six or eight inches of sand in these filters will have to be removed again, but as they have already run thirteen years and can probably run quite a number of years yet before this removal, it is, of course, a much less serious matter than if sand removal had to be resorted to frequently. The filters have been operated at a rate purposely kept low enough to prevent rapid and undue clogging. There is a great deal said at the present time in regard to the operation of sand filters at higher rates than followed with these filters, and many filters at Lawrence have been operated at higher rates. These higher rates mean simply, however, the more rapid clogging of the material and more frequent sand removal. For instance, we have operated at Lawrence for the past eight years a small filter to which septic sewage has been applied and the average rate of operation during this period has been 250 000 gal. per acre per day. During this period, we have had to remove sand twice on account of clogging and the sand removed has amounted to about 2.85 cu. yd. to each million gallons of sewage applied. The relation of the sewage applied to the suspended matter in the sand and sand removal has been as follows: There have been 805 lb. of this suspended matter in each million gallons of sewage, and we have had to remove for each 250 lb. of this suspended matter applied, 1 cu. yd. of sand in order that the filter might be operated at the high rate that I have just stated. Two other sand filters have been operated to which the effluents from trickling filters have been applied after these effluents have passed through tanks in order that a certain amount of sedimentation might take place. One of these filters has received this effluent at the rate of 600 000 gal. per acre daily, and one at the rate of 700 000 gal. per acre daily. In order to keep the rates up to this high point, we have had to remove from these filters about 3 cu. yd. of surface sand per million gallons of sewage applied. There has been about 200 lb. of suspended matter in each million gallons of the effluent of the

trickling filters applied to these sand filters, and in order to keep the rates at the high figures that I have just mentioned, we have had to remove a cubic yard of sand for every 70 lb. of suspended matter applied. These figures show that the amount of suspended matter removed from sewage that can be allowed to accumulate in the filter before sand removal becomes necessary decreases in amount very rapidly as the rate of filtration maintained is increased.

This is, perhaps, hardly a discussion of Mr. Eddy's paper, but I did not have a chance to read carefully the advance copy of it forwarded to me before this meeting, and I think you will all agree after hearing it that it is a paper that must be read very carefully in order to be able to discuss it to any great extent.

Prof. C.-E. A. Winslow. — I have listened with a great deal of interest to this paper. There is no more important question in sewage disposal than this question of the removal of suspended solids, and it is one for light on which we must look particularly to such experiments as those carried out at Worcester. I think that all of our laboratory and experiment station work, although trustworthy with regard to soluble constituents and the chemical changes which take place in sewage, is pretty sure to be more or less weak with regard to suspended solids, because the treatment of suspended solids on an experimental scale, where the sewage is pumped through a small, and it may be a complicated, pipe system, and possibly passed through one or two tanks, is very different from the problem on a large scale and under actual working conditions.

I do not like to say it in Professor Sedgwick's absence, but I think when I was a student at the Institute that he taught me there was no sludge produced in sand filtration. It seems pretty clear to-day that there is just as much sludge produced by that process as by any other process for the removal of solids. I was very much surprised when I began to look into the Brockton figures. They take from their beds alone nearly six tons of sludge per million gallons of sewage filtered, and that compares fairly well with the amount of sludge produced in chemical precipitation. It is always difficult to compare the results obtained at different places, and I should like at this time to suggest four things which ought to be studied in any consideration of the removal of solids, and about which data should be recorded in every paper on the subject. In the first place, in measuring the efficiency of the process, we ought to know always the number of parts per million of suspended matter in the

sewage and the per cent. of removal. Then, considering the sludge, I think we ought always to know the volume of sludge produced per volume of sewage treated and the percentage of solids in the sludge.

I took up two or three reports on my desk this afternoon and tried to compare results at Worcester with those at Columbus and with some of our own at the Technology experiment station. I found certain striking differences. At Worcester, with a treatment of sewage containing on the average about 300 parts of suspended matter per million, chemical precipitation took out 80 per cent., sedimentation only 52 per cent. and septic treatment 33 per cent. of the suspended solids. On the other hand, at Columbus, with 209 parts of suspended matter per million, chemical precipitation produced the same result, 81 per cent. removal, while sedimentation was more efficient and septic treatment much more efficient than at Worcester, each giving between 60 and 70 per cent. removal. At the Technology experiment station, with sewage containing 134 parts of solids, our septic tanks gave only 36 per cent. removal, about the same as the results at Worcester. The reason for these discrepancies I do not know — whether it is due to difference in the bacterial flora of the sewage, in its chemical composition or in the construction of the tanks. Any of those three things may operate.

In order to compare the character of the sludge produced I have prepared the following table. In the first column is the volume of sludge produced per million gallons of sewage treated; in the second column the percentage of solids in sludge, and in the third the number of parts of solid sludge per million parts of sewage treated.

Table Showing Amount and Character of Sludge from Various Processes.

| Place. | Process. | Volume Sludge per Million Volumes Sewage. | Per Cent. Solids in Sludge. | Solids in Sludge per Million Parts Sewage. |
|---|---|---|---|---|
| Worcester .... | C. P. | 4 900 | 8 | 400 |
| | S. T. | 500 | 6 | 30 |
| | Sed. | 2 500 | 6 | 150 |
| Columbus..... | C. P. | 2 300 | 8 | 180 |
| | S. T. | 540 | 15 | 80 |
| | Sed. | 1 100 | 13 | 140 |
| Boston........ | S. T. | 850–2 700 | 2 | 20–50 |

It will be noticed that the Worcester problem is particularly serious, the sludge produced by precipitation being much in excess of that at Columbus. This would naturally be expected

from the large amount of solids and trade wastes in the sewage. Comparing the three processes studied at Worcester, it appears that septic tank, sedimentation and chemical treatment stand to each other in the ratio of 10 : 50 : 133 with regard to the amount of solid sludge produced, a pretty good showing for the septic tank.

On the other hand, the Columbus results are quite anomalous. The sludge produced by chemical treatment is exceptionally small in amount and the septic tank solids abnormally large in proportion to sewage treated. Thus the ratios for solid sludge produced by septic tank, sedimentation and precipitation are 10 : 17 : 22.

On the whole it appears that at Worcester chemical treatment produces good purification with very heavy sludge, sedimentation a fair effluent with moderate sludge, and the septic tank a poorer effluent with very little sludge. At Columbus, on the other hand, the sludge produced by chemical treatment is small in amount and the sedimentation and septic processes produce effluents nearly as good as those from precipitation so that the processes are much more alike in their results. Our results with the septic tank at the Technology station are very like those attained at Worcester. The lower of the two figures for the amount of sludge is the one to be taken for comparison, for the larger one is for tanks operated at rates too slow for maximum efficiency. We have found that the slower the rate the less the solution of the sludge, other things being equal — I mean with rates covering periods varying between 12 and 48 hr. I should like to say in passing that I appreciate very fully what Mr. Carpenter has said about the error in measuring septic efficiency, due to the carrying over of suspended solids. We have found that a very important and a very serious factor, but it is a point which I think may be minimized by careful construction of the septic tank.

We have found in our experiments on the treatment of Boston sewage that at least three processes of sludge removal are probably necessary. As our experiments have gone on, the complex nature of the problem has become more and more apparent. In the first place, for the removal of heavy suspended solids there must be some sort of grit-chamber treatment. I agree with Mr. Carpenter that the more thorough and efficient this process is made the better off we are. If the road detritus can be got out in a condition in which it is comparatively harmless — that is, in which it is largely inorganic — it is a great

gain. We take out 0.65 cu. yd. or 130 gal. per million gallons of sewage treated against 0.16 cu. yd. or 32 gal. per million gallons of sewage treated, at Worcester, a considerably larger amount. Yet our grit-chamber detritus contains 73 per cent. of solid matter against 50 per cent. at Worcester, and ours is inoffensive in character, while that obtained at Worcester is not. I suppose this difference is due to the larger proportion of street washings in our sewage; at least, there must be a larger proportion of inorganic matter. Next, we find that septic treatment gives fairly good results for our purposes. Although we get only 36 per cent. removal of suspended solids, that appears to be sufficient to enable us to operate our trickling filters satisfactorily. I was interested to see in Mr. Whipple's paper last spring a reference to the hydrolytic tank at Hampton, England (constructed by the authorities after a suggestion made by Mr. Clark in the 1899 report of the Massachusetts State Board of Health), in which the sludge is separated from the sewage in a septic tank, made into three compartments, and the sludge is allowed to undergo a long anaërobic putrefaction, whereas the sewage passes off rapidly. Our experiments have, however, indicated that even the liquefaction of sludge is interfered with seriously by a too prolonged period of septic action. Finally, in our experiments a third process of sludge removal is necessary. Following the trickling filter there must be another period of sedimentation and a further production of sludge if a clear effluent is desired. In many cases that would not be essential. In discharging into a large stream, or into the sea, it would not be necessary, because the effluent which comes from the trickling filter though turbid is stable and well purified. The sludge, like that of the grit chamber, is inoffensive in character and may be easily disposed of on land.

There must always be sludge. There is no question about that. We have not yet found any process for entirely liquefying the suspended solids in sewage. The aim of sewage treatment must be to make the sludge as small in amount as possible and as nearly inoffensive in character. We have really only three main processes in the whole art of sewage treatment, and the problem for us to solve is the proper application of those three processes in different combinations. First, either by straining or sedimentation, or by that combination of straining and sedimentation which chemical sedimentation offers, we may separate the sludge from the liquid matter. Then the liquid part must be nitrified; and some of the sludge may be digested in the

septic tank. It seems to me that we ought to keep those processes separate in our minds, for all others are based on them,— straining or sedimentation for the separation of solid and liquid matter, septic treatment for the partial liquefaction of sludg and aërobic bacterial treatment for the oxidation of solids or liquids, or all combined.

Mr. Carpenter. — Just one thought occurred to me as I listened to the last speaker, which relates to the correct calculation of the total amount of sludge deposited in the septic tank. I question whether we do not, in some instances, give the septic tank credit for more than it accomplishes. When the septic tank is drawn down, preparatory to measuring the sludge, the effluent or liquid drawn off at that time will contain a large amount of matter in suspension. Do we always sample that and take account of the suspended matter that passes off in that way and add it to the sludges found in the tank? I did not do so at first.

Professor Winslow. — In our experiments we stirred up the entire contents of the septic tank and considered the whole septic tank contents as sludge, which is the reason our "sludge" contained only 2 per cent of solids.

Mr. Carpenter. — If your septic tank had been of considerable size, it would have been difficult to have stirred it up and have secured an average sample.

Mr. Fales. — In our septic tank, we took a small sample, and were very careful to draw it off at a time when there was a very large ebullition, and analyzed it and found it analyzed about the same — that is, for a 250 000-gal. rate, which was the lowest rate used.

Mr. Carpenter. — Did you take continuous samples?

Mr. Fales. — Yes, samples every 10 or 15 minutes. Then in regard to sampling the septic effluent, we sampled every hour; but I never noticed a time when the septic tank sent up a very large quantity of sludge as compared with the quantity sent up at other times. The results seemed to be very uniform, and in taking samples of the effluent I feel that we got good average samples throughout, taking it once an hour through periods of a month.

Mr. Carpenter. — Did you find at times that a large amount of sludge would come from the bottom to the top?

Mr. Fales. — Yes, after a rainstorm particularly; we found that a rain storm with wind would drive the sludge to the bottom and the next day it would nearly all be back again.

But it didn't take place in an hour. It would take place during a period of 24 or 48 hr.

Mr. Eddy. — It ought to be made plain that these hourly samples were continued through the 24 hr. of the day and every day in the period, and not during a 10-hr. day.

Mr. E. B. Phelps. — There have recently come under my observation two septic tanks which are so alike in their method of operation and so unlike in their results that they present an interesting problem. Both are situated in New Jersey; both were put in operation about the same time, in 1902. One is at Red Bank, N. J. This tank is a homemade affair, made out of an old gas holder, circular and about 43 ft. in diameter, with a conical bottom, so that the center depth is about 5 ft. and the depth at the edge about 9 ft. Its capacity is 100 000 gal., and the estimated daily flow of sewage is 250 000 gal., although that varies widely, there being a great deal of storm water, not only from surface openings but from leakage into the sewer. The tank was put in operation in 1902 and has never been touched from that day to this. At present there is almost nothing on the bottom, but on the surface there is a scum fully 2½ ft. thick of the cleanest, nicest sort of stuff I ever saw in a septic tank. It is supporting quite a growth of mushrooms and vegetable matter of different sorts, and, when broken into, presents an appearance not unlike garden soil — rich, sandy loam. Now, in contrast with that is the other tank I have in mind, which is located at Plainfield, N. J. It was built at the same time and has a capacity of about half a million gallons, with a daily flow of 1 000 000 gal., so that its period of storage is about 12 hr. That tank, from the time it went into operation to the present time has required cleaning at least twice a year and often more frequently. It collects immense volumes of sludge. The scum is a foot thick generally before cleaning, and this is exceedingly foul-smelling stuff, so that it is necessary to deodorize it with lime or something of that sort before it can be handled; and although it is located at a considerable distance out in the country, the nuisance is pretty bad; it is noticeable for a long distance — in fact, was very noticeable a quarter of a mile away when I was last there. Moreover, the Red Bank effluent was quite clear and free from suspended matter, while that from Plainfield contained more of such suspended material than one expects to see in a good tank effluent. I haven't any explanation to offer for the difference in the action of these tanks. The analyses of sewage are not dissimilar, and I can find no reason

for the difference, unless it be the fact that the tank I mentioned first, having a diameter of 43 ft., has a mean velocity through it of 86 ft. a day, and I suppose the maximum velocity is not over 100 ft.; the other tank is 100 ft. long, as I remember it, so that the velocity is over 200 ft. per day. Mr. Eddy's figures on sedimentation were interesting to me because they seemed to show more value in slow velocities and longer time than we had hitherto expected. I think it has been the general experience that after two or three hours' sedimentation the contents of the tank are not much further clarified in the next 24. Mr. Eddy finds that up to 24 hr. and longer, sedimentation is quite active, a very important matter. And that is the only thing I think of in this connection to explain the results. I thought it was a very interesting matter and worth presenting to you.

Mr. Weston. — I would ask Mr. Phelps if the character of the sewage in the two tanks he mentioned is the same with respect to its being manufacturing or domestic.

Mr. Phelps. — Yes, both are strictly domestic, so far as I know. The character of the analyses would indicate that the sewages are quite similar.

Mr. Carpenter. — There is one question I should like to ask Mr. Eddy, and that is as to the comparative quality of the effluents from the several methods of filtration.

Mr. Eddy. — That is going a little outside the scope of the paper, and for that reason it was not mentioned. The paper deals only with suspended matter. I should say that the quality of the effluent from the filters receiving the effluent from chemical precipitation was the best, as we have operated our filters. By way of explanation, I might say that we have only a very small proportion of the filtering area which would be necessary to treat all of our sewage, and our object in life is to get the best possible net result, which does not necessarily mean the highest degree of purity of effluent. That is, if we can get a large amount of water through our beds with a fair degree of purity we are obtaining better net results than if we get a higher degree of purity with a very small amount of water. Consequently, the question of purity is not as finely drawn as in other places. The filtrates from unsettled and settled sewage have not been very different, and in fact our effluents by the various processes have not varied materially in quality. None of them show a high degree of purity on account of the very large dosing which the filters have received. Our last annual report gives comparative rates for all the processes, does it not, Mr. Fales?

Mr. Fales. — Yes, comparative rates of flow and comparative analyses.

Mr. Eddy. — So that I should have to refer you to the report to get that question thoroughly answered. There was one other question raised by Mr. Carpenter which it might be interesting for me to touch on, and that is the question of furrowing beds for winter use, presumably largely to keep the ice off the surface. We accomplish the same thing without furrowing, by retaining on the surface of the beds a few of the piles of scrapings. That is, in the fall we take off just a sufficient number of piles to leave at regular intervals small heaps of scrapings, and those are sufficient to keep the ice off and accomplish the same result as by furrowing, thus avoiding mixing the large amount of organic matter in the surface layers with the cleaner sand below.

Mr. R. S. Weston. — Although the hour is quite late, the speaker would like to bring to mind the general question, namely, What is suspended matter? It has been shown that the effluent from the septic tank at Worcester clogs the filters faster than the effluent from the sedimentation tank. What is the reason for this?

German * and English † investigators perhaps give data which explain the experience at Worcester.

Fowler and Ardern showed that settled sewage contains 25 per cent. septic settled liquor, 47.6 per cent. of the organic matter in the form of colloids, as shown by the oxygen consumed test, and 52 and 61 per cent., respectively, as shown by the albuminoid ammonia test.

O'Shaughnessy and Kinnersley ‡ showed that the proportion of colloidal matter in samples of sewage varies greatly with various methods of treatment. Fecal liquors were found to contain from 46 to 86 per cent. of the organic matter in the form of colloids, while urine contained from about 7 to about 10 per cent. The organic matter in Birmingham crude sewage contains about 40 per cent of colloids on the average, the amount

* W. Blitz and O. Kroehnke: "Organic Colloids from Town Sewage." *Berichte der deutschen chemischen Gesellschaft*, Vol. xxxvii, p. 1745.

† Jones and Travis: "Elimination of Suspended Solids and Colloidal Matters from Sewage." Proceedings of the Institution of Civil Engineers, 1905–6.

Fowler and Ardern: "Suspended Matter in Sewage and Effluent" Journal Society of Chemical Industry, 1905, 483.

‡ "Journal Society of Chemical Industry, 1906, 719.

varying greatly with the character of the sewage, for while the organic matter in manufacturing waste contains only 7.5 per cent. of colloids, settled Ashton sewage, which is a stale domestic sewage, contains 72 per cent.

The investigators show that fecal matter passes into semi-solution or into the colloidal state upon agitation with water, and the amount passing over into the colloidal form depends upon the time of contact and the degree of agitation of the mixture of fecal matter and water. These authors believe that the action of the septic tank reduces the sludge by decreasing the true suspended matter and increasing the colloidal matter, more than by true anaërobic solution. Do not the results of these experiments explain some of the differences in efficiency obtained at various places? Do not analysts determine suspended matter differently? Do not the errors of determination obscure the lessons to be learned from many of our experiments, because one considers as dissolved what is really semi-soluble?

I think we can depend upon the accuracy of the experiments made abroad, and the practical bearing is important, because if sewage containing a large amount of colloidal matter be applied to disposal beds, it reseparates, sometimes beneath the surface of the bed, and causes clogging.

There is a great chance for study and development along this line. If the hypothesis is correct, then treatment of the sewage should be such as will produce the least colloidal matter. If this is true, the liquid portions of the sewage should be separated from the sludge as quickly as possible and, as Mr. Clark has suggested as long ago as 1898, the sludge should be treated separately. To express it differently, practice should aim toward getting as much matter as possible into the insoluble form as quickly as possible, removing it, and allowing the rest of the sewage to be treated on trickling filters or disposal beds.

It may be possible that the presence of colloids in septic tank effluents is a better explanation of the difficulties experienced in treating the same on disposal beds than is the theory that the toxins produced by the anaërobic bacteria in a septic tank inhibit the growth of the aërobic bacteria in the disposal beds, which belief has led to the construction of aërators between septic tank and disposal beds.

This paper certainly is very suggestive and throws much light upon a somewhat obscure problem.

Mr. Fales. — Mr. Carpenter states that analyses of the influent and effluent are likely to give the septic tank credit

for accomplishing more than it actually does on account of inaccurate sampling of the effluent. At times, as Mr. Carpenter suggests, a large amount of sludge rises in the tank, at which times an abnormal amount of suspended matter is carried out of the tank in the effluent. It is necessary to sample a fair proportion of this. I should think in order to obtain a fair sample of the septic tank effluent for a single day when the tank is in active fermentation, samples would need to be taken as often as every 15 minutes. Through a period of 4 weeks or more, if the samples are taken as they were in Worcester every hour, 24 hr. in the day, 7 days a week, I believe fair samples will be obtained.

MR. J. W. BUGBEE (*by letter*). — Owing to the fact that the sewage of Providence is pumped to an elevation of 27 ft. before its arrival at the precipitation tanks, no trouble with road detritus and other heavy sediment has been encountered as at Worcester, where the gravity system is in use. During the five years since the plant was put in operation, no sediment has accumulated in the tanks which could not be made to flow to the sludge ejectors, and be disposed of in the usual way, and the sludge drains and well yield only 5 or 10 yd. of sand in an annual cleaning.

A large sump in the main sewer, just above the pumping station, takes the place of the grit chambers, and the thorough screening which the sewage receives before passing to the pumps removes all the coarser floating matter.

The suspended matter remaining in the sewage is still further subdivided by the action of the pumps, and arrives at the tanks in the form of very small particles. For these reasons the sludge formed by the chemical treatment is more uniform in composition and contains a somewhat greater percentage of organic matter than is the case at Worcester.

Other points of difference in the Providence sewage are the absence of pickling liquids, and the presence of large amounts of waste from the woolen mills. This waste contains, in addition to dyestuffs, the wool-grease from the scouring-machines, and soap from the cloth washers.

The average amount of fat in the dried sludge has been found to be about 13 per cent.

The presence of large amounts of acid in the Worcester sewage probably accounts for the length of time (2 to 4 weeks) between cleanings of precipitation tanks, for it has been found necessary in Providence to clean all tanks at least once a week

in warm weather to prevent fermentation of the sludge. Also the lime necessary to assure economical pressing is less in Providence, as 60 lb. has been found to be the maximum amount required, even though septic action may have been going on for some time before the removal of the sludge from the precipitation tanks.

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[Note. Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk St., Boston, by January 1, 1907, for publication in a subsequent number of the Journal.]

## DISCUSSION ON MR. SPOFFORD'S PAPER, "THE NORTHERN BOUNDARY OF MASSACHUSETTS."

Mr. George A. King. — Several years since, while waiting on the wharf at the Weirs, my attention was attracted to a small structure at the outlet to Lake Winnepesaukee, and I copied the enclosed inscription found therein, which may be interesting.

ENDICOTT ROCK.
The name of
Iohn Endicott Gov.
and the initials of
Edward Johnson and Simon Willard
Commissioners
of the Massachusetts Bay Colony and
John Sherman and Jonathan Ince
Surveyors,
were inscribed upon this rock Aug. 1, 1652
to mark the head of Merrimack River.
A line three miles northward of this rock was
then claimed by that colony as the northern
limit of their patent.

E I S W
W P IOHN
ENDICVT
GOV
I S I I

The structure which covers
this historic stone long known
as Endicott Rock was erected
for its protection in 1892 by the
State of New Hampshire in
accordance with joint resolutions
of its legislature approved
Sept. 7, 1883 and Aug. 1885.
John Kimball, Erastus P. Jewell, Joseph B. Walker, Commrs.

Fred Brooks, Secretary. — Shortly before the sudden death of Mr. Spofford he submitted a draft of discussion which he had prepared in reply especially to Mr. Hodgdon's criticism, pages 16–19.

He remarked that the first half or more of his paper, ten pages out of sixteen, was a relation of simple historical facts.

He said that under the legislative enactments of Massachusetts, New Hampshire and Vermont, 1885–92, neither the

surveyors nor the commissioners were authorized to *change* any line; that they were not even authorized to survey a conventional line and suggest some changes that might be needed; that their business was solely to run the lines by the monuments, straight or crooked, to replace old monuments if required, and to furnish and set all new ones required, then to map their lines and to report the whole business to the legislatures of their respective states; that when he wrote the Resolve that passed the Massachusetts legislature in 1885 he had no idea that it would require the approval of Congress.

He asserted that he never said or wrote anywhere or at any time that two states were not competent to *establish* a state line, because it was a well-known principle of law that they could do it legally, precisely in the same manner that two towns could agree upon a boundary line, and two individuals also; that this was too simple a principle to need any illustration; and was a matter of daily occurrence between individuals.

His contention was that two states were not competent to *change* an established state line. He said that two individuals could not change the line between their respective premises without a deed signed by both parties and duly acknowledged; nor could two towns change a town line without authority from the state legislature; nor could two states *change* an established state line without the approval of Congress; and that in no other way and under no other circumstances could territory of one state be ceded to another state, whether the territory were one square foot or ten thousand square feet or square miles; and he cited the case of Boston Corner as a precedent that must be followed in all cases where territory was to be transferred from the jurisdiction of one state to that of another. He said he was well aware that this principle, apparently so simple, had been doubted by others.

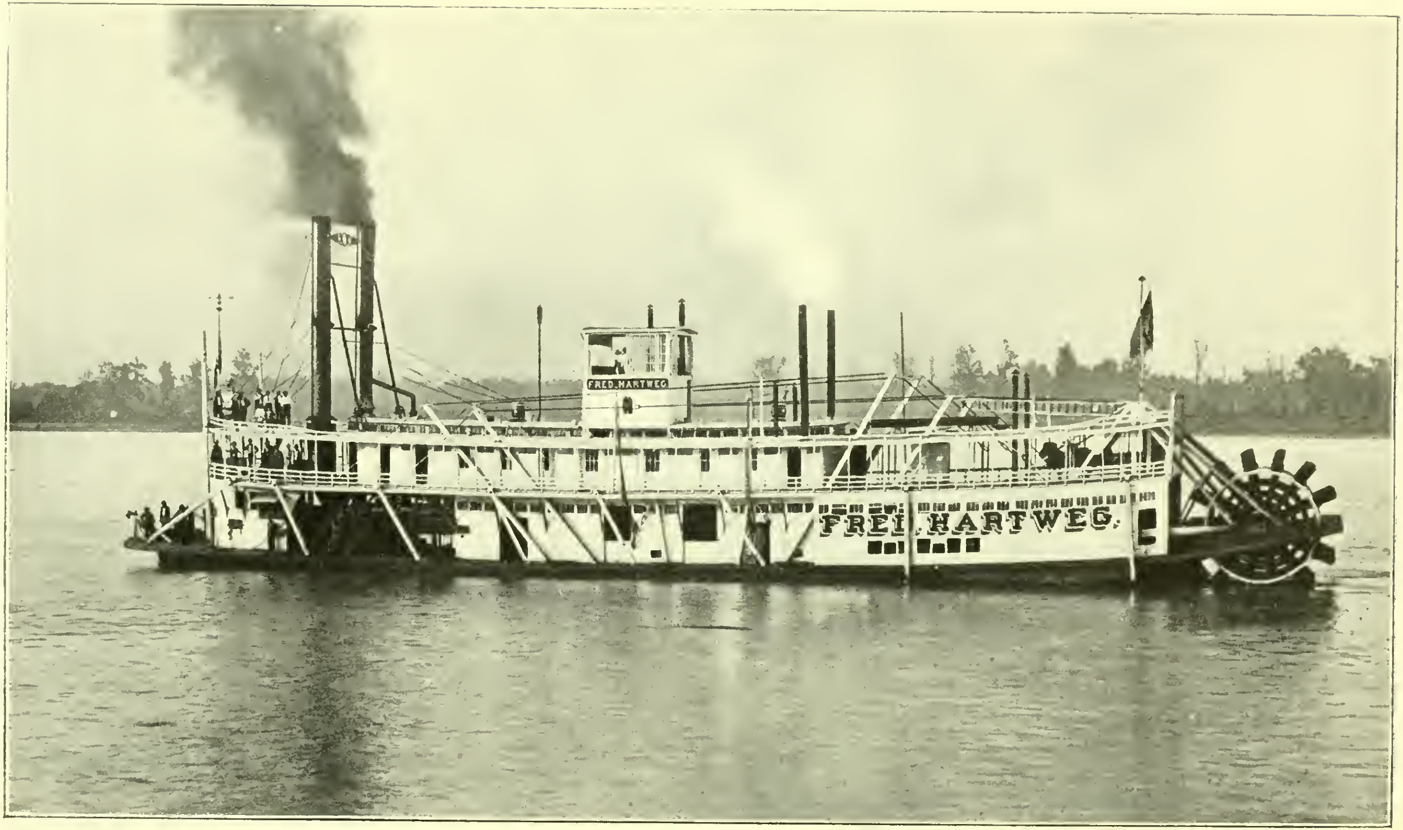


Fig. 1. Tow-boat "Fred. Hartweg": Length, 160 ft.; Beam, 29 ft.; Depth, $4\frac{1}{2}$ ft.; Built, 1896; 2 Engines; Cylinders, $18\frac{1}{2}$ in. by 7 ft.; 4 Boilers, 38 in. by 26 ft.

ASSOCIATION

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# THE WESTERN RIVER STEAMBOAT.

BY THE LATE A. H. BLAISDELL, MEMBER ENGINEERS' CLUB OF ST. LOUIS.

[Read before the Club, June 5, 1901.*]

THE type of American steamboat in use on the alluvial rivers of the West and South is often criticised. The criticism emanates, however, for the most part, from those who have given both the rivers and the boats but little study. A comparatively short experience on our rivers never fails, I have observed, in convincing the intelligent critic that our steamboat is admirably adapted for the work it is called upon to perform. The great fluctuation in stage of water, the rapid currents, the caving banks, the constant shifting of channels, the hazard of snags and flows of heavy drift, the very shoal water over crossings during much of the navigable season, the impossibility of maintaining more than a few improved landings, render the adoption of the conventional type of tide-water steamboat infeasible on alluvial rivers. The western river type of steamer is the result of a long series of trials and errors, and, until very recent years at least, it has been a well-established fact that it not only carried a greater amount of freight on a given draft of water, but that its cost of construction and outfit per ton of freight capacity was less than that of any other type of steamboat constructed in the world.

The average life of a western river hull, built of oak, does not exceed 12 years, and after a service of about 4 years its annual repair aggregates more than its first cost. The engines

*It is necessary to omit in publication a number of the illustrations that accompanied this paper.— SECRETARY, ASSOCIATION OF ENGINEERING SOCIETIES.

outlast the hulls several times over, and it is not unusual that engines are doing duty on their third or fourth hull to-day. On eastern waters a life of 40 years for a wooden steamboat hull is not uncommon.

Previously to the keen competition of railroads in the West, when river traffic was very extensive, the business was predicated on expectation tables of partial and complete loss based on experience. The hazards attending navigation are well exhibited in the list of steamboat wrecks on the Missouri River which have occurred since 1819. The total number of wrecks from all causes is 300, of which 210 were from snags and hidden rocks, 26 from ice, 26 from fire, 6 from boiler explosion, 10 from collision with bridges and 22 miscellaneous.

The early form of propelling machinery, the horizontal, long stroke, high-pressure, non-condensing engine, still holds its place, and rightly so; many improvements in parts have been made, but the type remains as best adapted to a service which requires primarily lightness, rapid action, absolute reliability, simplicity in construction, capability of easy repair and economy of space. There are apparent crudities in parts of the machinery, and mention is often made of the iron-strapped wooden connecting rod and the "doctor" feed pump. A trial to design a substitute for the wooden pitman, combining equal lightness and stiffness, will convince the skeptical of the fruitlessness of his effort. The "doctor" pump, with its pan or coil heater supported on its water columns, can be criticised only on account of its weight; its feed is slow and sure, and all its working parts are readily accessible and easily repaired. A lighter pattern of "doctor" pump, without the heater attachment, is in use on some few boats, but a light, inexpensive and satisfactory heater, so far as I know, has not yet been devised.

In regard to boilers, experience indicates that the externally fired, horizontal cylindrical boiler with large return flues is the best adapted for service on our silt-bearing streams, and appears to justify a former law which prohibited the use of any other type of boiler on vessels navigating rivers flowing into the Gulf of Mexico. At present, however, owing probably to superior material and workmanship, the law allows many other types of boiler to be used, and also permits an increase in thickness of shell of the externally fired boiler from a previous limit of 0.26 in. to 0.30 in. Many instances may be cited, and some of very recent date, of boilers of the locomotive type, the Scotch marine, the Clyde and other types, combining in their con-

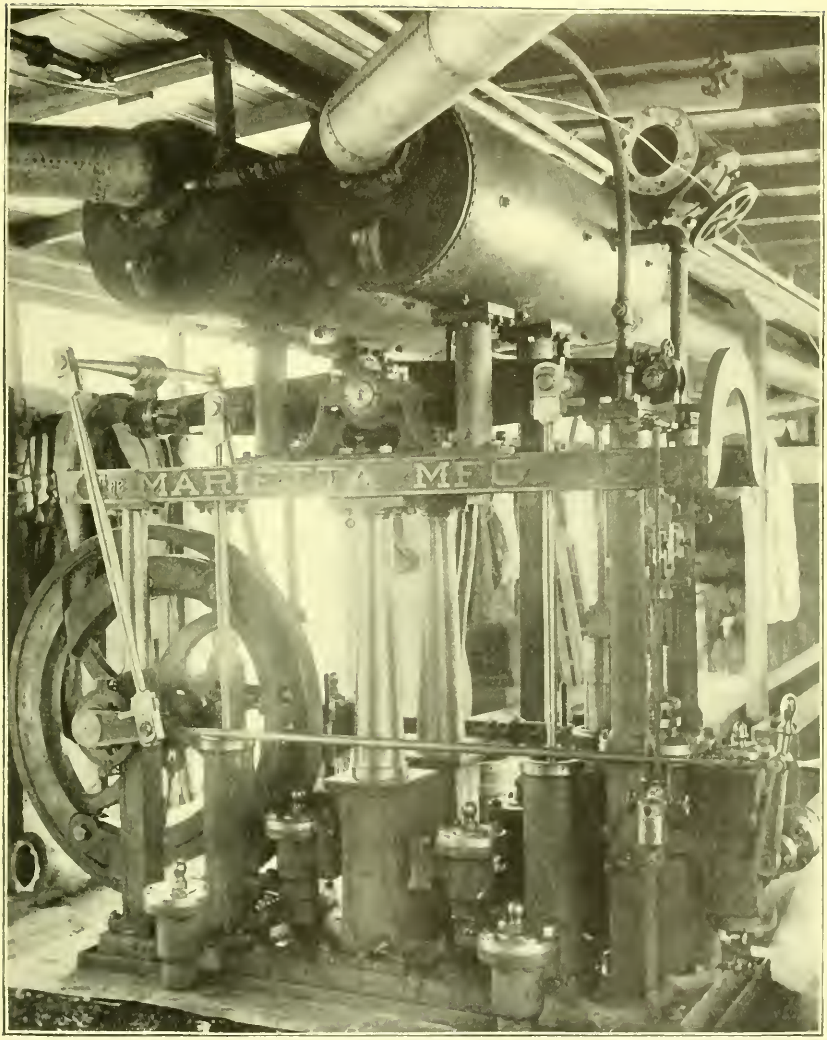

FIG. 4. A "DOCTOR" FEED PUMP.

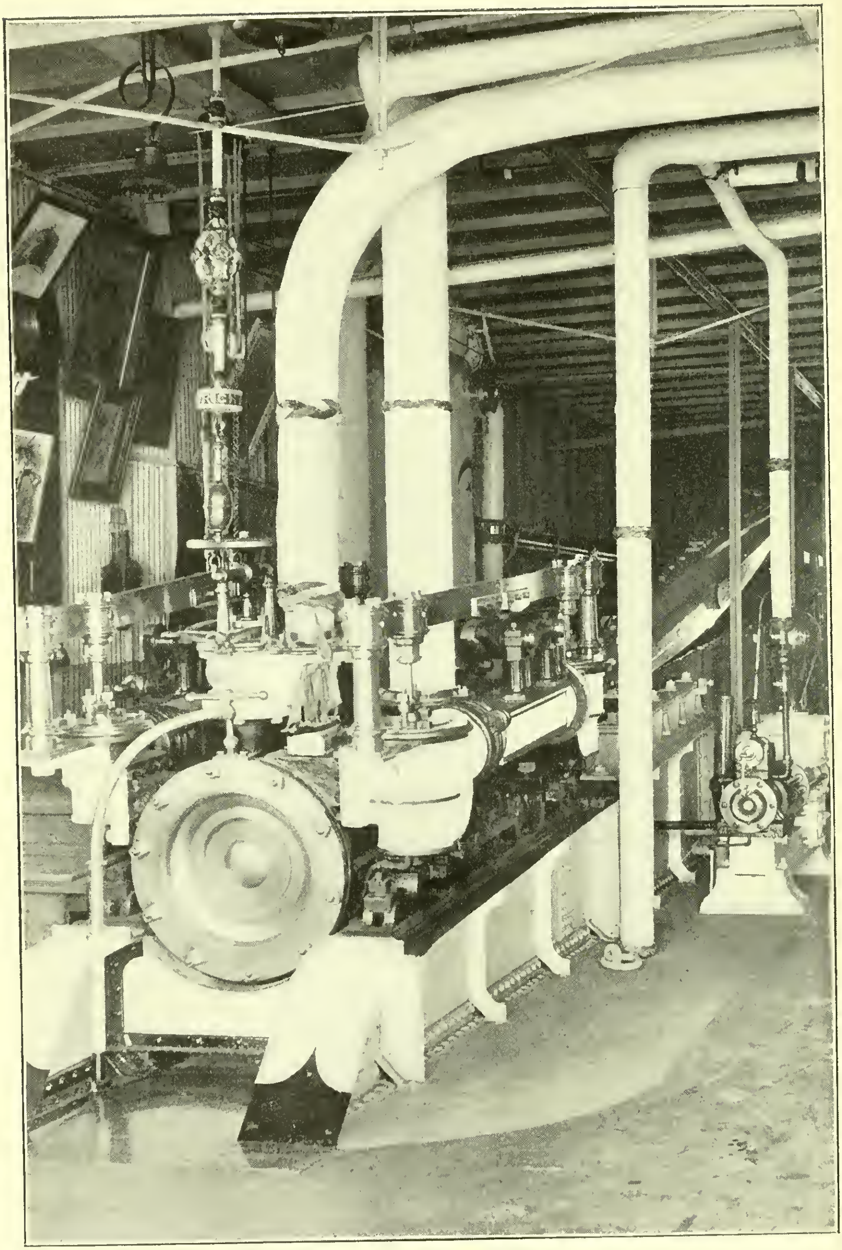

FIG. 3. ONE OF THE ENGINES OF THE U. S. SNAG-BOAT "H. G. WRIGHT."

struction the best of material and workmanship, proving complete failures in western river service, and being supplanted by the common type of externally fired horizontal boiler. The water-tube boiler has not yet, in my opinion, received a fair test on our western rivers, and whatever improvement in steam generators we may expect in the near future lies, I think, in the proper application of the water-tube type.

Passing now to the hull of the western river boat; the wooden hull admits of but little variation in manner of construction, and consists essentially of cross frames, to which the skin and deck are attached and over which are run the bulkheads, keelsons, stringers and other longitudinal fastenings. The small available depth and the nature of the material indicate a deficiency in longitudinal strength; this is made up, at least for hogging strains, by chains on each side along the cabin bulkheads, carried up above the hurricane roof and one or more interior chains under the cabin floor. The model of the hull depended on the intended service of the boat, and, perhaps above all other parts, was the result of experience. The superintendents of the different boat yards were known as specialists in some particular type of boat; as a rule their mold-loft practice was jealously guarded, and the few apprentices admitted had to rely much more on their individual effort than on instruction to gain any insight into the geometry of boat building. With no knowledge of descriptive geometry as taught in books; with an entire innocence of any definite ideas of the relative positions of centers of gravity of weights and displacement; with, generally, a contempt for any aid from mathematics or science, it is quite wonderful how expert these men became as constructors. In their best boats the scientific constructor will find but few things to condemn as regards either model or disposition and use of material. Modern literature is prolific in fulsome praise of the visible executive officers in our marine and river service, and perhaps their merits have not been too highly extolled; but the constructor and the engineer, whose duties are too material to be gushed over and too complicated to be popularly understood, are seldom mentioned and never appreciated.

In respect to the performance of western river steamers there are but few on which complete tests have been made, and of these but few details are available. The only complete tests of which I have knowledge are those made personally by Col. Charles R. Suter of the Corps of Engineers, United States Army,

than whom there is none better equipped, by experience and theoretical knowledge, to write a treatise on the subject of this paper. The tests made on one of his boats, the United States dredge boat *Octavia* (Fig. 6), were made a precedent in subsequent designs in the practice of his office. The wooden hull steamer *Octavia* was built at St. Louis, Mo., in 1866, for the "mountain" (Fort Benton) trade. Her general dimensions were: Length between perpendiculars, 199 ft. 8⅝ in.; beam, 36 ft.; depth of hold, 6 ft. She had two engines 20 in. diameter by 6 ft. stroke; three externally fired, cylindrical boilers 44 in. diameter by 24 ft. long, each containing 6 return flues, 2 of 10.5 in.; 2 of 9.5 in. and 2 of 7.5 in. diameter respectively; two side wheels, 24 ft. diameter by 10.5 ft. length of bucket; 16 buckets varying in width from 22 in. to 12 in. The boat was of the general type of successful merchant boats then building, and, because of her full forward lines, was well adapted for carrying and operating the heavy long scraper on her bow, for which use the government bought her. She had made but one trip to the mountains, the profits of which are said to have more than covered her original cost, before she was purchased by the United States. The boat was in no way remarkable except that her builders appear to have struck a happy mean in proportioning her hull and machinery. On a trial trip of 4 hours' duration in 1874, the following results were obtained:

| | |
|---|---|
| Mean draft of boat | 32½ in. |
| Area immersed surface | 7 001 sq. ft. |
| Displacement | 508.6 tons |
| Mean speed in still water | 9.78 miles per hr. |
| Mean dip of wheels | 27½ in. |
| Mean pressure (by gage) | 134 lb. |
| Mean number of revolutions | 18⅛ |
| Indicated horse-power | 396.37 |
| Grate surface | 52 sq. ft. |
| Heating surface | 1 744 sq. ft. |
| Coal burned per hr. per sq. ft. of grate | 29 lb. |
| Water evaporated from 212 degrees fahr. per lb. of coal | 6.16 lb. |
| Coal burned per hr. per i.h.p. | 3.79 lb. |
| Slip of wheel | 33.7 per cent. |

The tests of a more recent boat are those of the stern-wheel iron steamer *Mississippi* (see Fig. 11), belonging to the Mississippi River Commission. This boat was built by the firm of Allen & Blaisdell, St. Louis, Mo., in 1882. Two purposes were to be combined in her construction — that of an inspection steamer having large cabin capacity, and that of a tow-boat.

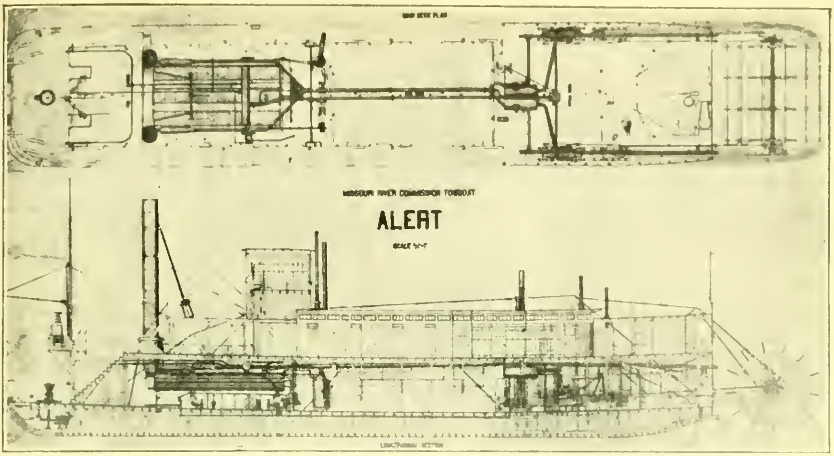


FIG. 2. WOODEN TOW-BOAT "ALERT," OF THE MISSOURI RIVER COMMISSION: DIMENSIONS, 132 FT. BY 24 FT. BY $4\frac{1}{2}$ FT.; ENGINES, 15 IN. DIAMETER BY 6 FT. STROKE; 3 BOILERS, 40 IN. BY 24 FT., EACH CONTAINING TWO 9-IN. AND TWO 11-IN. FLUES.

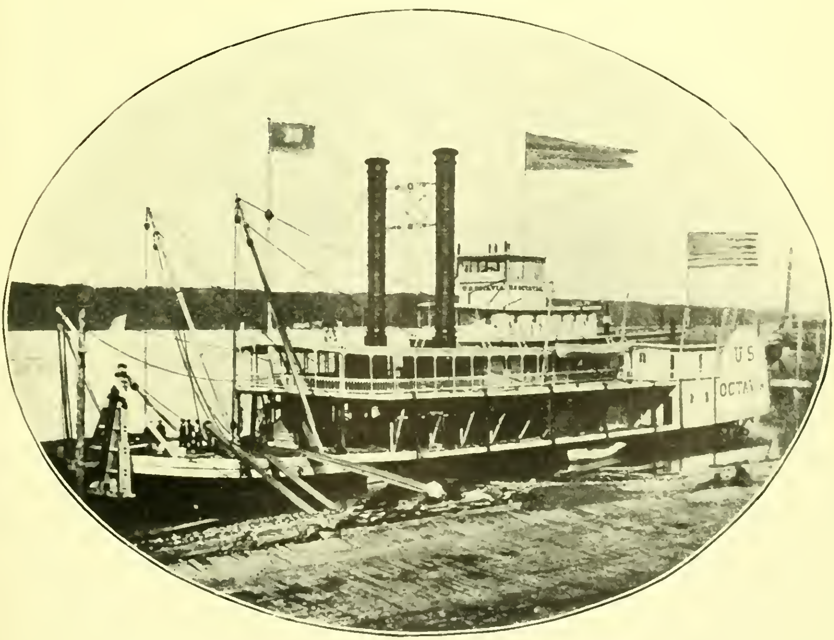


FIG. 6.

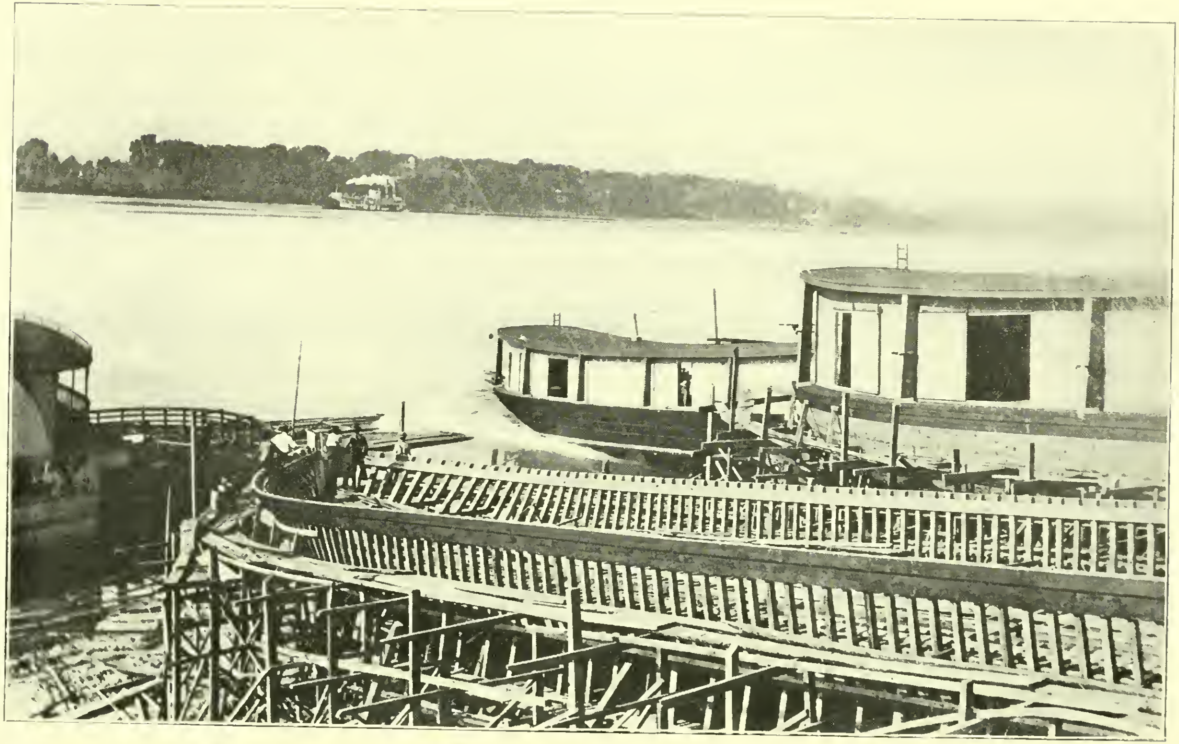

Fig. 5. Barges of the Mississippi Valley Transportation Co. Dimensions, 225 ft. by 36 ft. by 10 ft. Launching of Barge "Commerce," Howard's Shipyard, Jeffersonville, Ind., 1891.

U.S. STEAMER "MISSISSIPPI"

LINES

AS MEASURED FROM MOULD LOFT

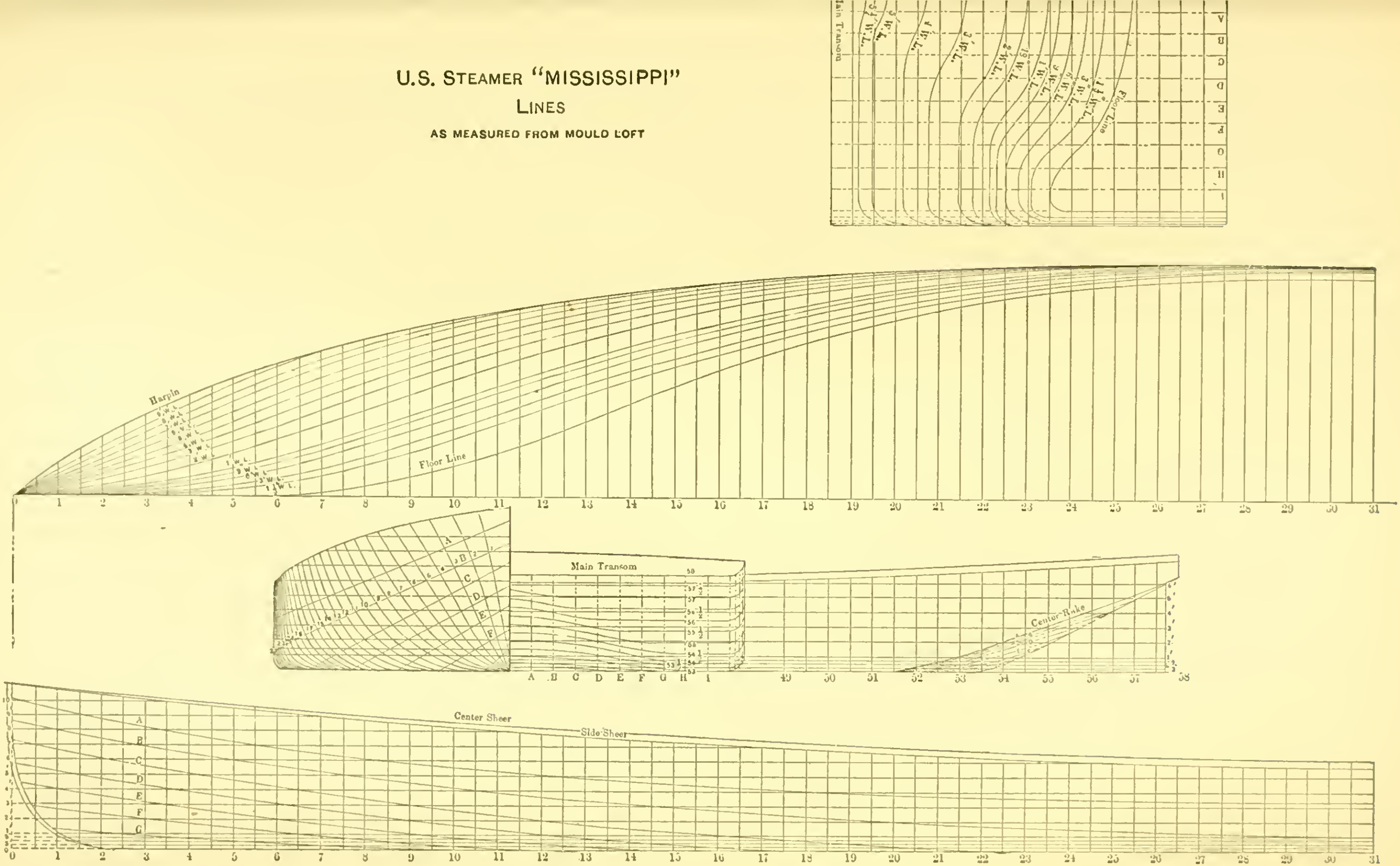


FIG. 7.

The sum of \$45 000 only was available for her construction, and the work was undertaken with the understanding that her

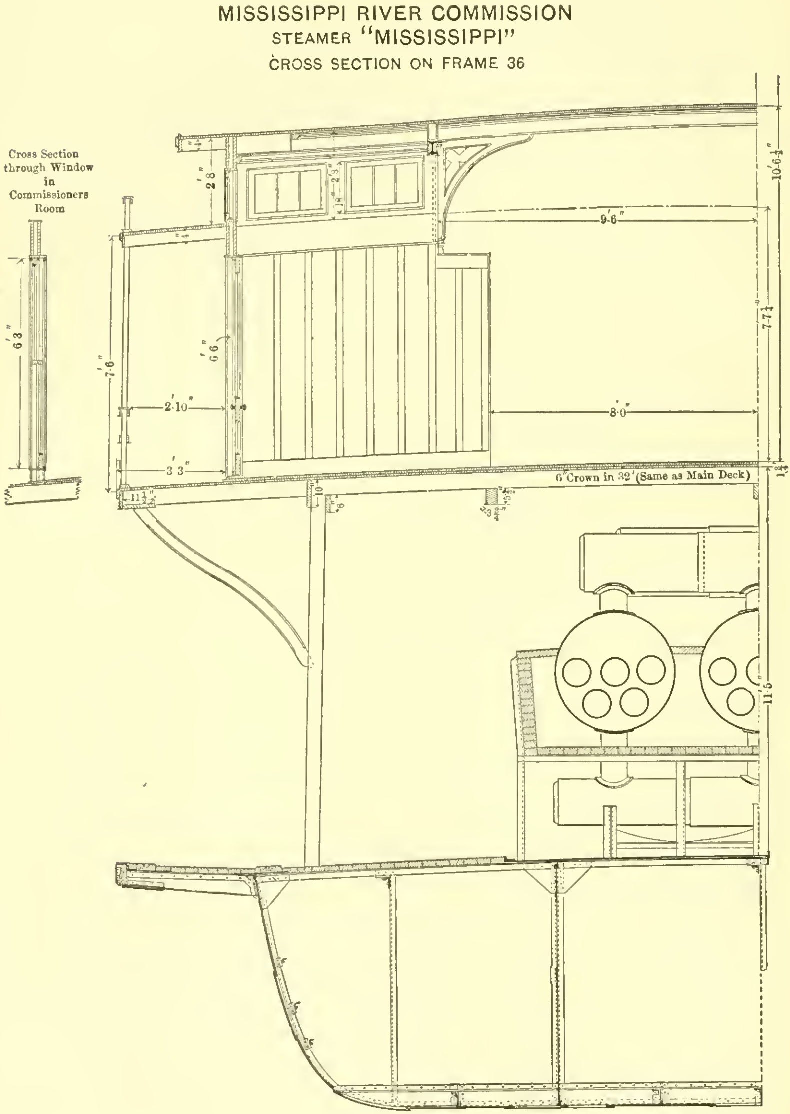


FIG. 8.

engines were to be second-hand ones, 20 in. diameter by 6 ft. stroke, which were then in store of a St. Louis wrecking company. The engines were formerly on the steamer *St. Joseph*,

which was built in 1865 and was wrecked in 1880; and, judging from their condition, might have had service previous to that

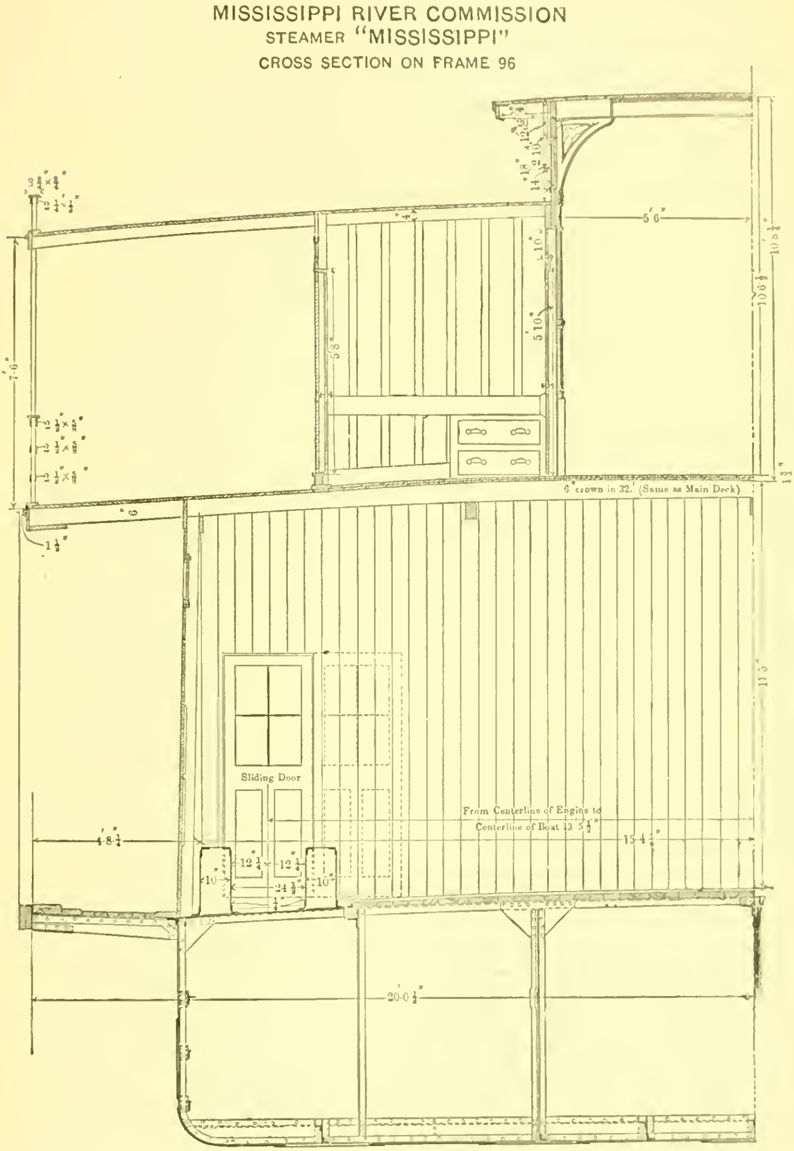


FIG. 9.

date. So many renewals were found to be necessary, including one new cylinder, that money would have been saved to the builders had entirely new machinery been purchased. Had

the cost of the boat not been so limited, her engines would not have been less than 22 in. diameter by 7 ft. stroke. Her general dimensions were: Length between perpendiculars, 174 ft.; length over all, 201 ft.; beam, molded, 32 ft.; beam, over

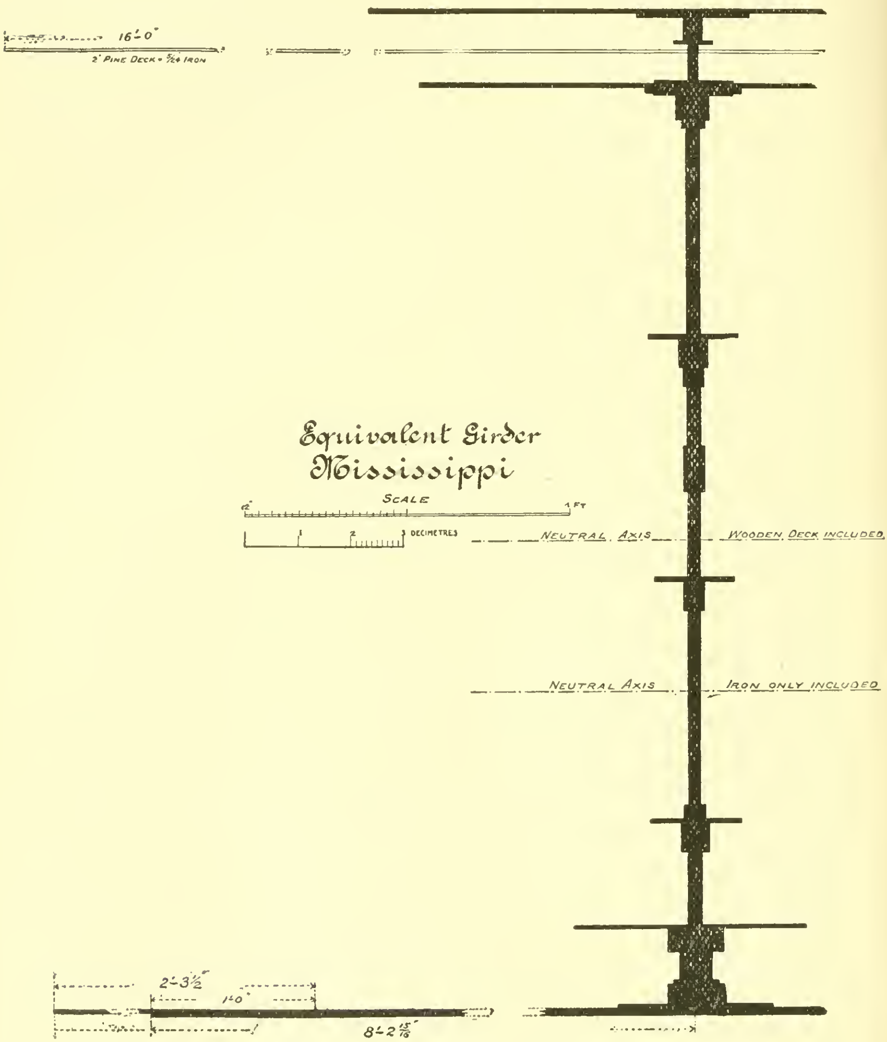


Fig. 10.

guards, $40\frac{2}{3}$ ft.; depth, 6 ft.; sheer, forward, 5 ft.; sheer, aft, 2 ft. Two engines, 20 in. diameter by 6 ft. stroke. Three boilers, 42 in. diameter by $28\frac{1}{3}$ ft. long, each containing 5 10-in. diameter flues. Maximum steam pressure allowed, 160

lb. Grate area, 61.4 sq. ft. Heating surface, 1 714 sq. ft. Stern wheel, 22 ft. diameter by 20⅜ ft. length of bucket; 20 buckets, 24 in. in width.

The hull is constructed on the longitudinal system, with 2 longitudinal bulkheads. In the extreme portions of the bow and stern, beyond the collision cross-bulkheads, the transverse frames are brought down to the skin and made continuous for facility in construction, but the longitudinal strength is amply maintained over the cross floors. The strains which come on a boat are longitudinal, and it certainly appears logical to treat the hull as a girder. The deck of the boat is of white pine, but heavy iron plank sheers and stringer plates are run over the gunwales and bulkheads. The wooden deck is an important factor in the strength of this boat, as by iron butt-straps it is made practically one piece, excepting for the hatch openings. In calculations for strength it is usual to consider $\frac{5}{48}$ of the thickness of the wooden deck as its equivalent in iron. It will be seen in the drawing of the equivalent girder (Fig. 10) that the position of the neutral axis is well placed to resist either a hogging or a sagging strain, to either of which the boat may be subjected.

The following are the results of her trial trip, made immediately before she was put in commission, in May, 1882:

| | |
|---|---|
| Draft of boat | 46 in. forward and 40 in. aft |
| Area of wetted surface | 5 330 sq. ft. |
| Displacement | 454.7 tons |
| Boiler pressure | 160 lb. |
| Mean pressure in cylinders | 105.47 lb. |
| Revolutions per minute | 21⅝ |
| Indicated horse-power | 507.95 |
| Speed per hr. in still water | 12.41 miles |
| Slip of wheel | 22.2 per cent. |
| Coal burned per hr. per i.h.p | 4.385 lb. |
| Coal burned per hr. per sq. ft. of grate | 39.596 lb. |
| Water evaporated from 212 degrees fahr. per lb. of coal | 4.64 lb. |

The coal was the common steamboat coal furnished in this harbor.

Applying Rankine's formula for the resistance in pounds to the motion of a ship in water,

$$R = K.A.V^2,$$

in which $V$ is the velocity of the vessel in knots; $A$, the augmented surface, = the wetted surface multiplied by 1 + a variable dependent on the mean sine of the angle of entrance; K, a coefficient for frictional resistance of clean painted iron at a

speed of 1 knot, = 0.01; and placing the ratio of the net h.p. to the i.h.p. at 0.613, a value determined by experiments of Rankine and others, the maximum speed to be expected for the *Mississippi* from the i.h.p. developed on the trial is 12.55 miles per hr.

In 1893 the entire upper works and most of the main deck were burned while the boat lay in winter quarters. Her hull, boilers and machinery were comparatively uninjured and she was brought to St. Louis and fitted out with a more extensive cabin, a Texas was added, and she was generally overhauled.

In 1898 her old boilers were replaced with a new battery of 3 boilers, 44 in. diameter by 28.5 ft. long, each containing $\frac{3}{9}$ in. and $\frac{2}{11}$ in. diameter flues, but having an additional thickness of shell which increased the allowable pressure to 180 lb. Fig. 11 shows the present appearance of the boat and its much criticised wheel.

The club members will recall a series of running tests made with the steamer, detailed by Mr. F. B. Maltby in his paper read March 7, 1900, on the Operations of the Hydraulic Dredges of the Mississippi River,* which he had made with a view of a possible reduction in the number of buckets or of the bucket area. I regret that this portion of his paper was not published. I reproduce his tabulated results here.

Mr. Maltby's summation of his tests was that the bucket arrangement in test No. 3 was untenable on account of the excessive vibration given to the boat, and that, in the last test, the gain in speed of only 0.2 mile per hr. did not justify the increased expenditure of 10 per cent. in h. p. necessary to maintain it. Mr. Maltby's tests were interesting and instructive, and it is to be regretted that further trials were not made with an even reduction of bucket area and with split buckets. The original wheel had 24-in. buckets. These were then increased to 27 in., and finally, from some unknown process of reasoning, the arrangement of 30 in. and 24 in., which Mr. Maltby found in use when he took charge of the boat, was adopted. A varying width of bucket may be made on stern-wheel boats — as is always done on side-wheel boats — to balance the varying direction of pressure and the weights of the cranks and pitmen, but I can see no reason for alternating in even widths.

The number of arms in a 22-ft. diameter wheel, when built according to ship carpenter's rule, would be about 0.8 of the

*Journal Association of Engineering Societies, Vol. xxiv, p. 299, May, 1900.

number of feet in the diameter, or 17; but I know of no steamboat on which this rule has been observed where the vibrations are not uncomfortable to the passenger and also detrimental to the boat and to its speed. Using a formula which presumes one effective bucket to be immersed at all times, and equates the resistance of water per sq. ft. of paddle surface and the mass of water moved multiplied by the distance it is moved, and using the data obtained in the two trials, widths of bucket of 24 in. and of 28.8 in. result respectively, for the 1882 and the 1899 trials. In regard to the number of paddles, 20 in a 22-ft. diameter wheel is large in western river practice, but is frequently exceeded elsewhere. On the *Mississippi*, 4 buckets are more or less submerged at one time, and this number obtains with many boats. On the *Mary Powell*, of the Hudson River, while the buckets are 3.5 in. farther apart than on the *Mississippi*, 6 of them are in the water at one time.

The slip of the most efficient paddle wheel is rarely under 15 per cent. The steamer *New York*, of the Hudson River, is reported to have this slip while running in still water;

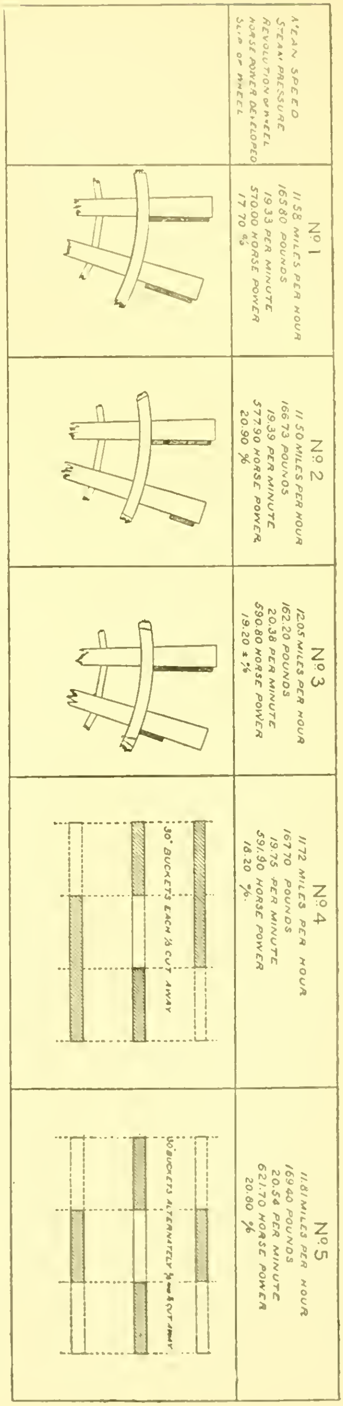


Fig. 12. Tests of Steamer "Mississippi" at Memphis, Tenn., January, 1899.

her wheels have feathering paddles. (She will make 24 miles per hr. if pressed.) Fig. 13 shows the paths of the paddles

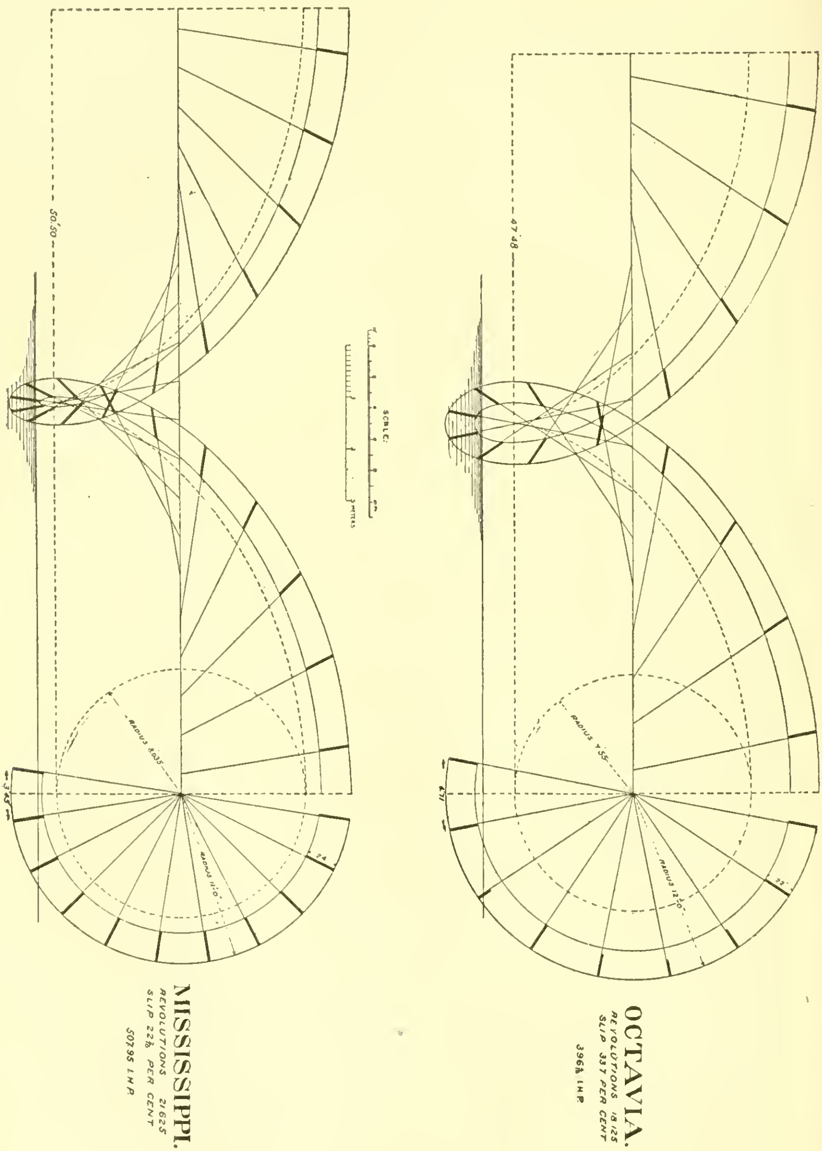


Fig. 13.

during one revolution of the wheel, as observed on the trials of the *Octavia* and the *Mississippi*.

The *Mississippi*, in trial No. 1 of 1899, with buckets alternating 30 in. and 24 in. in width, showed the least percentage of slip, viz., 17.7 per cent. In regard to slip, the best result which has come to my knowledge on western river boats was obtained on the trial of the small iron steamer *Itasca*, built by Allen & Blaisdell in 1881. She has 2 engines, 10 in. diameter by 4 ft. stroke; stern wheel, 12⅔ ft. diameter with 16 buckets 10.75 ft. long by 12 in. wide and making 26.5 revolutions; she gave a mean speed of 9.35 miles per hr. in still water with a slip of 16 per cent.

I do not look for a greater speed for the *Mississippi* in her present condition of rough skin, draft of about 4 ft. and an i.h.p. of 570, than 12.1 miles per hr., which value is obtained from Rankine's formula by giving a value of 0.012 to the frictional coefficient. We have seen that the present wheel of the boat compares favorably with the best practice as regards slip, and, in my judgment, any possible improvement lies in the direction of a uniform width of bucket of 28 in., or possibly of a split bucket, which might permit a slight increase in the piston speed, and not in a reduction in the number of paddles.

To those interested in the financial side of boat building I add a few figures respecting the cost of building the hull of the *Mississippi*. Into the construction of the hull there entered:

| | |
|---|---|
| 219 234 lb. of plate iron, costing delivered | 3.54c. per lb. |
| 153 135 lb. of angle and bar, costing delivered | 3.64c. per lb. |
| 22 272 lb. of rivets, costing delivered | 5.5c. per lb. |
| 5 317 lb. of cast iron, costing delivered | 3.03c. per lb. |
| 7 470 lb. of steel shaft, costing delivered | 10.7c. per lb. |
| 1 225 lb. of hydraulic tube (rudder stocks), costing delivered | 5.2c. per lb. |

The cost per lb. for labor was 4.12c., divided as follows:

| | |
|---|---|
| Mold loft | 1.02c. |
| Machine shop and blacksmith | 0.95c. |
| Fitting | 0.91c. |
| Riveting and calking | 0.69c. |
| Shoring, handling, painting and proportion of yard and shop expenses | 0.55c. |

The results of the *Octavia's* machinery tests may be regarded as illustrating fair practice, and will compare favorably with many land steam plants, but they, of course, bear no comparison with those obtained from quadruple expansion engines and the higher type of water-tube boilers, where as low as 1.5 lb. of coal per hr. to the i.h.p. has been obtained. There are quite a number

of western river boats, especially on the Ohio River, which have compound engines; they are said to be very efficient, but I am not in possession of any detailed tests of them.

The Missouri River snag-boat *C. R. Suter* (Fig. 14) has compound oscillating engines, which are in every way effective for a side-wheel boat and are particularly adapted for that stream, where rapid action is always necessary, and where, with the ordinary long-stroke engine, the engineer is not infrequently three or four bells behind the pilot's signals. The first cost of these oscillators, of course, largely exceeded that of the common type of engines, and their weights are probably about the same, but we estimate that they save about 100 bu. of coal in a day's run. Taking, however, into consideration the facilities our rivers afford of obtaining cheap fuel at short intervals, the saving of fuel, in which direction recent improvement in machinery has been mostly directed, becomes relatively unimportant when compared to other expenses, and I look for no material change in the type of our boats except in the substitution of well-constructed steel hulls in place of wood.

It may be of interest to the club if I outline the general method of designing a steamboat hull, using an actual case occurring in the practice of the office with which I am connected. The wooden tow-boat *Wm. Stone*, built in 1883, near Pittsburg, was purchased by the United States for the Missouri River improvement. Her dimensions were 136 ft. long by 26 ft. beam by 4 ft. 9 in. depth. In 1892, with steam up and 14 tons of coal on board, she drew 52 in. forward and 34 in. aft, a draft which rendered her almost useless for low-water service. In 1895 she was completely rotted beyond repair, and was wrecked. Her engines were 15¼ in. diameter by 7 ft. stroke, driving a wheel 19 ft. diameter, with 14 buckets, 18.25 ft. long by 28 in. wide. It was desired to design for this machinery a steel hull, which, having large cabin capacity, fully outfitted with stores and supplies and carrying about 25 tons of coal in the forward bunker, should have a maximum draft of not over 32 in. Without going into details, a displacement of about 300 tons would be required, and the dimensions of the boat decided on were: Length 147 ft., width of floor about 27 ft. and a central depth of 4.5 ft. In selecting the form of the midship section I was guided by a previous calculation of the relative curves of stability of the two forms shown in Fig. 15. In 1895, when called on to design a new hull for the United States survey steamer *Patrol*, Mr. Ockerson, of the Mississippi River Commission, sug-

FIG. 14. U. S. SNAG-BOAT "C. R. SUTER" AS VIEWED FROM ABOVE.

FIG. 11.

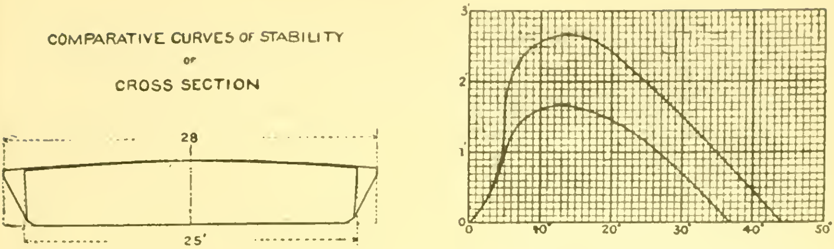


Fig. 15.

gested a wide flaring side without guards in place of the slight flare with guards usual in boats of this type. The abscissæ in the diagram represent the inclination to the vertical in degrees, and the ordinates represent the lengths of the lever arm of the righting moment in feet. The flaring cross-section was adopted for the *Patrol*, and a similar one for the boat under consideration.

In selecting a guiding or main water line, it is my custom to make it a mathematical curve. In the adapted general equation of the parabola

$$\beta = b\left(1 - \frac{y^n}{l^n}\right)^q$$

in which $\beta$ is any ordinate; $b$, the half breadth; $y$, the abscissa, and $l$, the length of entrance, by varying the power, $q$, and the exponent, $n$, any variety of line may be produced. Nystrom, in his "Mechanics," gives a few tables derived from this formula, in very convenient form for use. On the *Patrol* the 2 ft. water line is the curve where $q = 1$ and $n = 3.5$; on the boat being described, $q = 1$ and $n = 2.75$ for the same line, and both are parabolas. When $q$ is greater than 1, the lines become hollow, and are called paracymas. On the *Mississippi* the 2-ft. water line has $q = 1.5$ and $n = 2.375$. The ruling water line and the desired harpin or deck line being obtained, the construction of the other water lines and frame lines of the forward body is the work of the skillful draftsman.

The rake of the stern may be any curve, but I have found it good practice to make the change in direction rather abrupt under water, with a straight line tangent above. All stern-wheel boats have one or more balanced rudders, and when these turn on a vertical axis, in order to preserve a uniform distance from the rake, the forward part of the blade should recess into

the hull. If this is not done, floating drift may find lodgment between the hull and blade and block the rudder. If the rudder turns on an axis at right angles to the rake line, no recess is, of course, required. My drawings show an inclined rudder post for the boat I am considering, but I advocate this arrangement only for small boats, and I shall change the design to vertically-hung rudders.

The diagrams that are to follow illustrate some of the successive steps in the design of the boat. From the drawings of the lines calculations are made, as shown in Fig. 16, of the curves

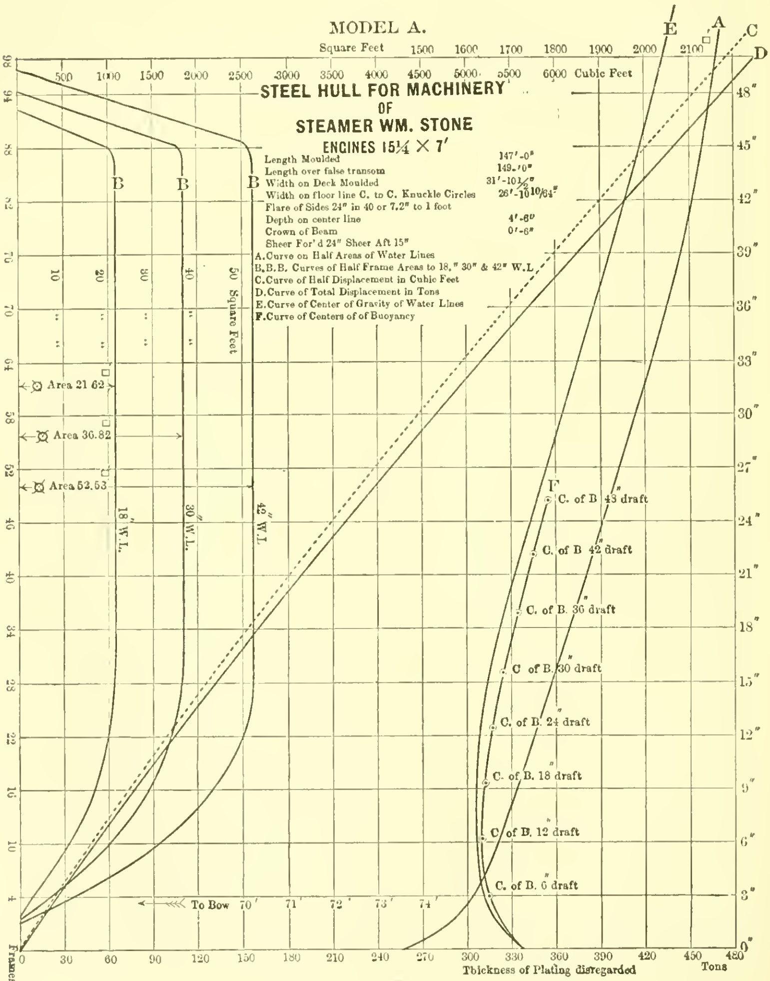


Fig. 16.

of areas of water lines and frames, of displacement, of centers of gravity of water lines and the locus of the centers of buoyancy.

The hull is treated as a girder, the web of which is composed of the fore and aft bulkheads and sides and the longitudinal floors and stringers; and the flanges of the girder are the bottom skin and the deck. The cross frames may be said to serve as stiffening brackets to the girder. At the ends of the hull, for practical reasons, the cross frames are made continuous across the boat, and the longitudinal strength is kept up by longitudinals worked on top of the cross floors. The equivalent girder, though differing in its details bears a general resemblance to that shown in Fig. 10 for the *Mississippi*.

On a stern-wheel boat the location of almost every item above deck is fixed except the boiler group, which at best can be moved a few feet only in either direction. On a merchant boat the freight to be carried is an important factor in the trim, but on a tow boat, if an even draft is desired, the forward lines must be such that the center of buoyancy shall not be brought so far forward that it would require an impracticable weight to bring

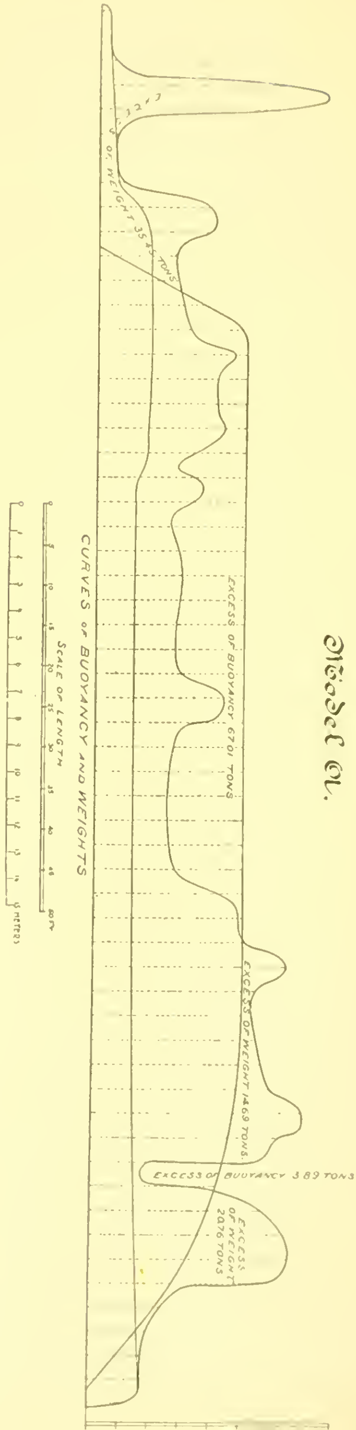


FIG. 17.

the centers of weight and buoyancy into the same vertical line.

The weights of the boat may be approximately stated as follows: Hull, 116 tons; cabin, 40 tons, machinery, 22 tons; wheel. 14 tons; stores and outfit, 30 tons; boilers, 53 tons; coal to make even draft, 25 tons; in all, 300 tons, which, from the scale of displacement, corresponds to an even draft of 32 in.

Further calculations are made for curves of buoyancy and weight, shown in Fig. 17. The upper regular curve is the curve of buoyancy. Each ordinate represents, to scale, the buoyant effort of each foot of length of the hull to a draft of 32 in. The lower regular curve is the curve of weight of the hull alone, and the irregular curve is the curve of weights of the entire boat with its load. The areas of excess in weights and in buoyancy are marked in the figure, and the aggregate of one must, of course, be equal to that of the other. By laying off the differences of the ordinates of the weights and the buoyancy, from a common line, in a plus and minus direction respectively, we have the line shown in Fig. 18, which is called the curve of loads. Here again the areas above the line, representing the buoyancy, must be equal to the areas below the line, representing the weights, and the common center of gravity of all the loops is in the ordinate which contains the centers of gravity of weights and of displacement. The curve of loads shows the manner in which the boat, considered as a beam, is loaded and supported. Between the forward end of the boilers and the coal bin there is a short space over which the buoyancy is greater than the weight, but the main points of support are just aft of the boilers and about 10 ft. forward of the transom.

From the curve of loads we pass by construction to the curve of sheering stresses, which are, of course, maximum at points of support. The point where the stress curve crosses the horizontal line is the point of reverse racking, and this marks the point of the hull on each side of which the boat is separately water-borne; the areas of the curve of sheering stresses on each side of the racking point must, of course, be equal. From the curve of sheering stresses we pass similarly to the curve of bending moments shown in the regular curve of the figure. The maximum bending moment at the racking point, as scaled, is 1 582.3 ft.-tons. The moment of inertia of the equivalent girder about its neutral axis is 2 558.6; whence, under the conditions considered, the extreme portion of the boat's deck would be subjected to a tension strain of 1.7 tons per sq. in.

Model A.

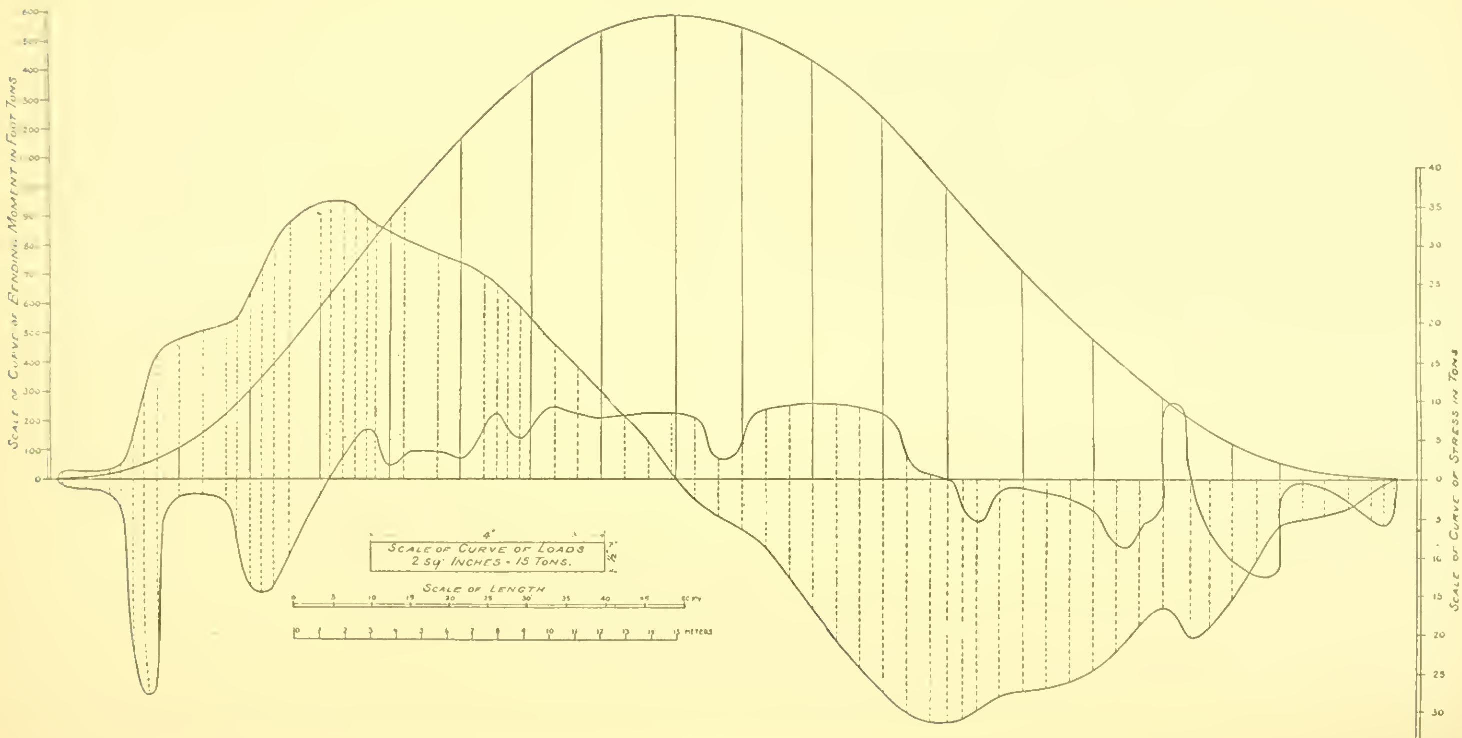


Fig. 18.

The strains we have considered are, however, those only for the boat lying at rest in still water, and it would be difficult indeed to do more than approximate to the strains to which the boat may be subjected by shocks of grounding when under headway.

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[NOTE. Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk St., Boston, by January 15, 1907, for publication in a subsequent number of the JOURNAL.]

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# THE DEVELOPMENT OF WOOD BLOCK PAVEMENTS IN THE UNITED STATES.

BY FREDERIC ARNOLD KUMMER, M. AM. SOC. C. E.

[Read before the Boston Society of Civil Engineers, November 21, 1906.]

IN tracing the rather slow development of wood block pavements in the United States it is necessary to deal with a number of stages in this development which did not exist in the evolution of this pavement abroad. It is because of the differences which existed between the development of this class of pavement abroad and in this country that the use of modern wood pavements in the United States has been so greatly retarded.

The English and continental engineers have always been ultra-conservative in the matter of making their constructions of all kinds permanent, while in this country, owing to its very rapid development, forms of construction in all kinds of engineering work have been adopted which were clearly not of a permanent nature, but which, under the circumstances, seemed desirable, if not indeed necessary, for the time being. Therefore, when foreign engineers began to lay pavements of wood, they placed rectilinear blocks upon heavy concrete foundations. In the earlier practice the blocks were not treated at all, and later only insufficiently treated, but owing to the permanence of the concrete foundations placed under them they gave good results from the start, and hence the development of such pavements abroad progressed along smooth and easy lines, involving only such changes as the employment of selected woods, the dipping of the blocks in antiseptic or bituminous compounds and ultimately the treatment of the block by creosoting. Under these

circumstances wood pavements rapidly attained a great popularity, especially in England and France, and the good results which they have given have caused them to become more widely used, especially in those two countries, than any other form of smooth pavement. It is a fact no doubt well known to you all, that most of the streets in London and Paris are paved with wood block laid according to certain established rules which will be mentioned later.

The development of the pavement in the United States has followed widely different lines. Perhaps the first use of wood for road purposes may be found in the corduroy roads built by the pioneers in making their way through the forests. The next development came in sawing the logs so used into short sections 8 to 12 in. long and setting these with the grain vertical upon the earth foundation. Pavements laid in this manner, with the joints and spaces between the round blocks filled with gravel, and in some cases gravel and tar, presented a fairly smooth and uniform surface for travel, and if the character of the timber used was of such a nature that decay took place slowly, such as was found to be the case with cedar and some other woods, this pavement retained a passable surface for a considerable period of time, especially where the sub-grade was of such a nature and so drained that the paving surface did not sink in spots and become irregular. Such a form of construction may appear to us very crude, and from an engineering standpoint in all respects faulty, but with the conditions to be met it was probably the best thing that could be done, since these newly established and poor communities could not possibly have afforded to lay pavements on a concrete base of treated rectilinear blocks, because at that period in the history of this country the expense would have been prohibitive, and the materials for concrete as well as the materials and apparatus for sawing and treating blocks were not available. Pavements of this form were very widely used throughout the country, but in the eastern states, as the prosperity of that section increased, they gradually disappeared. They existed in great quantities in Chicago at the time of the great fire and are still laid in many sections of the western part of the United States. As a sort of a side issue from this form of construction, and because of certain peculiar conditions, pavements of round sawed blocks on a concrete base are still being laid in some parts of the United States. In Detroit, for instance, it becomes necessary for the property owners to lay the first pavement on a street, after which the repaving is done by the

city at large. On many streets of this character round cedar blocks are placed on a concrete base because of their cheapness. I understand that they are laid for about 50 cents a square yard. They give a fairly serviceable pavement for about five years, after which the city places on the existing concrete base some suitable and more expensive smooth pavement. The use of blocks in this way is, however, an off-shoot from the steady development of the wood block idea throughout the country. After the gradual disappearance throughout the east of the old cedar and other round block, wood pavements were not heard of to any great extent for a considerable period. Shortly after the Civil War efforts were made to introduce a rectilinear wooden block under a system generally known as the Nicholson pavement. For this form of construction there was no excuse, and the fact that it was laid to an enormous extent throughout the country is not a great credit to the intelligence of our engineers at that period. The Nicholson pavement was laid as follows: The surface of the roadway was shaped up to crown and grade, but was usually not rolled and therefore was not sufficiently unyielding to permit of the laying of a block pavement upon it. To overcome this difficulty promoters of the Nicholson pavement placed a layer of wooden planks 1 in. thick over the surface of the roadway. These planks were not treated in any way, and it should have been evident to any one that they would rapidly rot out. The blocks placed upon this foundation were of various woods, whatever happened to be the most convenient at hand, and were merely short sections of timber sawed from the ends of planks of varying width, dipped in hot tar and set in place, with intervals of from $\frac{1}{4}$ to $\frac{1}{2}$ of an inch between the blocks, these intervals or joints being filled with tar and gravel. When first laid they presented a smooth and uniform surface to drive over and obtained a great deal of popularity. In the course of two or three years they failed completely because of the rotting of the blocks and the rotting and sinking of the plank foundation. Enormous quantities were used in most of our eastern cities. Elizabeth, N. J., is still paying interest on bonds for improvements of this character. Almost all the streets in Washington, D. C., were paved in this manner, and only about two years ago the writer came across a section of this pavement in Brooklyn where an asphalt pavement had been laid over the top of the old Nicholson block. The asphalt was being removed and the block and planking, most of which were completely rotted away, had been exposed.

It is doubtful if any form of pavement construction could have been devised which contained more faults and fewer merits than this Nicholson pavement. From the ground up it had not one feature to recommend it. The loose and uncompacted character of the foundation was against it, the use of the planking as a foundation inevitably meant rot and failure, the dipping of the block in hot tar was the worst thing that could possibly have been done and was the surest method of making decay as rapid as possible, and the laying of the block with an open joint served only to admit water and cause the under-planking to rot more rapidly than it otherwise would have done. It is possible that the statement just made regarding the dipping of the blocks in tar may not be completely understood. The fact is, that these blocks were very largely of green timber, full of sap, and as soon as the blocks were dipped in the mixture of hot tar, the pores of the wood were sealed up and the escape of this sap and moisture in the wood prevented. The immediate result was the fermentation of the sap with resulting dry rot. Most of the block collapsed like punk inside of three or four years. Had this pavement been laid without dipping the blocks in tar, they could have seasoned to some extent in place and would have had only the failure of the foundation to contend with, or had the blocks been seasoned by air drying for a period of a year before being laid and then dipped in hot tar, their life would have been considerably greater. As I have stated above, the use of this pavement in such enormous quantities was not a credit to American engineers. The theory of creosoting and preservation of wood was well understood in England and on the Continent at this time, and it should have been evident to any one that the results which followed the use of this pavement were inevitable.

Shortly after such an experience with wood pavements there began an eager search for some form of construction which would give smooth pavements which were at the same time durable, and about this time asphalt pavements were introduced into the United States and the use of wood almost entirely disappeared. This was the condition which existed in the United States about twelve years ago, when the use of creosoted wooden blocks on a concrete foundation was again taken up. Prior to this time some small sections of this pavement had been laid, notably in Galveston and New Orleans, where facilities for creosoting the blocks existed. The attention of the authorities of Indianapolis, Ind., was called to the results which this pavement had given, through the existence in Indianapolis of a small

creosoting works, and blocks treated with small quantities of creosote oil were laid in some streets on concrete foundations. This use of blocks of this character marks almost the beginning of the intelligent use of wood pavements in this country. In the period which has elapsed since then, the popularity of the pavement has grown enormously, and it is estimated that 1 500 000 sq. yd. were laid during the past year.

The writer first became interested in the subject of pavements of this character about seven years ago. A thorough canvass of the condition of the art at that time indicated that four important elements entered into the construction of a first-class pavement of this character. These elements are as follows: First, the foundation. Second, the character of the wood employed. Third, the character and amount of the treatment. Fourth, the method of laying the block.

Naturally, in any attempt to lay pavements of this character, a careful study of what had been done up to date was necessary. It was found that abroad foundations were almost uniformly of Portland cement, ranging in depth from 6 to 8 in., although in some cases heavier foundations were used. With the exception of reducing the depth of the foundation to from 4 to 6 in., depending upon the character of the sub-foundation and the nature of the traffic, no improvement seemed possible in the construction of this part of the pavement.

With reference to the character of the wood employed, it was found that abroad certain hard woods from Australia, known as karri and jarrah woods, were used to considerable extent untreated, while considerably softer woods, such as Norway pine and native French pines, were employed untreated, or merely dipped in hot creosote oil or boiled in same, or treated under pressure with from 8 to 10 lb. of oil per cu. ft. It was felt that the Australian woods untreated would be subject to decay, although these woods are of such character that they decay much less rapidly than most varieties of timber. Their use in England is not now as great as it formerly was. They are used to a very small extent in France and are not liked in Germany, although an Australian wood known as tallow wood is used to a limited extent. At the same time, it was felt that the soft deals and woods of the pine family were not sufficiently rigid and had not sufficient resistance to abrasion to make them entirely suitable for heavy travel. About this time enormous quantities of southern pine, known as long-leaf or Georgia pine, began to come into the eastern market, owing to the rapid cutting out of

the white pine forests of Michigan and throughout that territory, and in this wood, owing both to its plentiful supply and its toughness and hardness and adaptability for the reception of creosote oil, there existed an ideal wood for the manufacture of paving blocks. It was determined, however, that blocks of this character must be made of the heart of the tree only, as the sap wood, being much softer than the heart, would tend to wear away more rapidly and produce uneven wear on the surface of the pavement. At that time all-heart long-leaf yellow pine was readily obtainable in large quantities at prices about $10 per 1 000 less than would now have to be paid for similar lumber containing quite a high percentage of sap. The all-heart lumber, owing to the great demand for this character of material, is out of the market except at prohibitive prices.

Coming to the question of the nature and amount of treatment to be employed, it was found that owing to the absorption of water many of the streets laid in the early history of the business, treated with 8 or 10 lb. of straight creosote oil to the cubic foot, absorbed considerable quantities of water, resulting in swelling up after heavy rains, buckled so that the surface was destroyed, and often these pavements got into a dangerous condition. To remedy this difficulty it was determined in the first place that the block must be as completely filled with preservative material as it would permit; that is, all the pores of each individual block should be thoroughly filled with the oil. It was also felt that ordinary straight creosote oil, the dead oil of coal tar of commerce, was not sufficiently waterproof to properly exclude moisture from the block; and to overcome this difficulty melted rosin was introduced along with the oil, the two materials making a perfect mixture, which not only impregnated all parts of the block, but sealed up the pores so that moisture was excluded and the fiber of the wood stiffened and rendered better able to resist impact and abrasions. The proportion of rosin used at first was from 50 to 60 per cent., but the general practice at the present time is to use about 25 per cent., the reduction in the amount of rosin being made possible by improving the quality of the oil used. Some of the lighter creosote oils are of such a low specific gravity that they require 50 per cent. of rosin to render them sufficiently dense to thoroughly seal up the pores of the wood and prevent the entrance of water; but by specifying oils of very high boiling points, very heavy and dense and non-volatile oils may be secured which do not require such a high percentage of rosin. This change does not in any

way impair the value of the treatment, and at the same time prevents the cost of the block from running to a prohibitive figure, owing to the fact that rosin has advanced several hundred per cent. in value during the past few years, and at its present value, if 50 per cent. of it were used, the cost of the pavement would be needlessly increased. Inasmuch as wood pavements are already high in first cost, any unnecessary increase in their cost would operate to decrease their use by municipal authorities.

Coming to the question of the method of laying, it was found that the almost universal practice abroad was to lay the blocks with a joint between them of from about $\frac{1}{4}$ to $\frac{1}{2}$ of an inch in width, this joint being secured by putting small separating lugs on the sides of the blocks, or more generally by using wooden strips between the courses, these strips being afterwards removed and the joints filled with gravel and coal tar or pitch. This method is still widely used abroad, especially with the untreated or Australian woods, although with treated blocks the practice of laying the pavement with tight joints is now coming into favor. The idea of the wide joint was twofold. *First*, to render the very hard and slippery surface of the Australian hard woods less slippery by providing grooves across the street, and *second*, to allow room for expansion in case the blocks absorbed water. This second purpose was never fulfilled by a wide joint, and it seems strange that engineers could have ever supposed it would be. The reason is as follows: If the joint is packed tight with gravel and tar and the usual dirt existing on the surface of the street, it becomes practically as solid as the block, and if the blocks expand, the joint has no elasticity, and consequently the expansion is not taken up and acts in the same way as if the joint were tight. Furthermore, with wide joints there is a much greater chance of expansion than with tight joints, as it presents an opening for the water to soak through the pavement and lie on top of the concrete and be gradually absorbed by the block, whereas with tight joints the water, instead of getting under the block, runs off to the gutters. The writer has always believed that it is better to prevent expansion by so treating the blocks that they will absorb the minimum amount of water rather than by providing means to take it up after it occurs. It is still necessary, however, under certain conditions, to use an expansion joint.

Working out the problem along these lines, it was determined to lay blocks as thoroughly treated as possible, with perfectly tight joints, using only very clean fine sand to fill up any

crevices in the pavement surface which might exist. It was also thought best, in conformity with the usual English practice, to lay the blocks at right angles to the curb line except at intersections.

The first wood pavements laid in the East were laid on a sand cushion, as is the case with brick and stone. These pavements require a sand cushion, as they are not elastic enough to be set upon a rigid concrete base, but wood blocks, being in themselves elastic, are better laid upon a rigid foundation without the use of a sand cushion. This, of course, requires the block to be all cut to a uniform depth, but when laid in this way there is no danger of the cushion shifting, and also if any water gets through the surface of the pavement it does not have an opportunity to collect in the sand cushion and be absorbed by capillary attraction into the block. It is most essential in the case of wood pavements, perhaps more so than in the case of any other form of pavement, that the surface be kept uniform. The English practice is to float the surface of the concrete with a mortar, which mortar is allowed to become hard and smooth like the surface of a granolithic sidewalk, before the blocks are laid, and in many cases this mortar surface is covered with a layer of hot pitch in which the blocks are set. I am inclined to believe that this is a very excellent form of construction, probably better, although somewhat more expensive, than that now generally employed in this country. The usual method here is to true up the surface of the concrete in the same way with a mortar bed, but this bed is mixed damp instead of wet, and the blocks are laid in it before it has set and then tamped with an asphalt rammer until the surface is smooth and even. A certain amount of the mortar is squeezed up between the joints at the bottom of the block and closes this joint so that water cannot work its way under the block.

The English blocks are almost uniformly 3 in. wide, 9 in. long, running as high in depth as 6 in. It was felt that soft pine blocks of this depth would wear much more rapidly than blocks of Georgia pine, heavily treated, and it was concluded that 4 in. was amply deep for the heaviest travel. The first blocks were made 4 in. wide, 8 in. long, instead of 9 in., it being somewhat easier to get all-heart yellow pine planks of the smaller width. They were also cut 4 in. deep, but it was found that there was a constant tendency on the part of the workmen to lay them with the grain the wrong way, the dimensions as to width and depth being the same. The width of the block was therefore changed, some three or four years ago, to 3 in., making a standard block

Tremont Street, Boston, from Park Street.

A Roadway of Williamsburg Bridge, New York City.

3 in. wide, 8 in. long and 4 in. deep. Experience with blocks of the character of timber and treatment mentioned above on one of your principal streets, Tremont Street, has shown the rate of wear to be so small after six years that I believe that the blocks 3½ in. deep, now used almost universally as a standard throughout the East, are amply heavy provided the character of the timber used and the quality of the treatment are maintained.

Still another modification in the size of the blocks has been introduced in some of our largest cities. The increasing scarcity of available timber for manufacturing blocks has rendered it more and more difficult to get blocks 8 in. long of the quality desired, and it has been thought that the pavement would not in any way suffer if blocks of random lengths from 6 to 10 in. were employed, but in laying these blocks care must be taken that the joints are properly broken.

Coming to the question of the joints between the blocks, in my opinion nothing is superior to clean fine sand, used either very dry or hot and thoroughly swept into the joints; but unless the sand is of especially good quality — clean, very fine and dry — a cement grout joint will give better results. The sand joint, however, can only be employed on streets of considerable travel, where the action of the traffic can be depended upon to expand the head of the blocks sufficiently to practically close up the joints. On streets of light travel this action does not take place, the blocks sometimes get loose and absorb water, and, no matter how thoroughly they are treated, the accumulation of a very small expansion in each block over a considerable distance may produce some disturbance of the pavement. On light traveled streets some form of pitch joint is desirable. If hot paving cement is spread carefully over the surface of the street and swept into the joints with a squeegee, and the surface then quickly covered while the pitch is hot with a layer of sand or fine screenings, good results will be secured, but experience has shown that it is almost impossible to use pitch in this way in cold weather. Most of it remains on the surface of the pavement and later, when the weather gets warm, this becomes so sticky and disagreeable that much annoyance is caused to pedestrians and property owners. It is possible to pour the joints from a can, but unless this work is very carefully done most of the pitch will still be on the surface of the block. The company with which the writer is connected is now paving some streets in Baltimore, Md., where the surface of the streets is swept with hot pitch, as above described, on which is placed fine granite screenings, after the

English practice, the idea being that these screenings will be crushed into the joints and into the surface of the blocks by travel, tending to reduce any slipperiness which may exist on these streets. The streets in question have sufficient grade to render them a little slippery in wet weather.

It will be seen from the above that there are no very vital differences between the methods of laying wood block in this country and abroad, although it should always be remembered that the English and continental practice is to use very much less oil in the block than is used in this country, 10 lb. to the cubic foot being a maximum, as against 20 to 22 here. The English engineers have been approaching the American practice by using tight joints and shallower blocks, 4-in. blocks being used very largely there now, while formerly 5- or 6-in. blocks were being used, while the American engineers, by adopting the mortar bed and the use of granite screenings on the surface of the pavement instead of sand, are on their side approaching the English practice.

The above résumé of some of the lines along which wood block pavements have progressed does not, of course, cover all of the questions which have come up from time to time. One of the most important of these is the kind of timber to be employed for the blocks. All-heart long-leaf yellow pine seemed at one time to be the ideal wood for this class of work, but the rapid increase in the use of pine in all classes of construction work, and the diminution of the supply, have raised the price of timber of this character to a point where it cannot be used in large quantities for the manufacture of paving blocks except at very high prices. Naturally this condition has resulted in an effort on the part of wood block manufacturers to find other woods than pine which will fulfill the requirements for the manufacture of paving blocks. Tests are being made on a number of woods, such as Norway pine and tamarack in the northwest, and other tests are proposed, embracing short-leaf pine, loblolly pine, beech, maple, scrub pine and scrub oak. Of all the woods which have been considered, the black gum of the South seems to promise the best results. This is the wood which is now being laid on Washington Street in your city. It is a very tough, hard wood, with an irregular grain, and if used in the shape of planks is badly subject to warping. Used in the shape of blocks it seems to have no disadvantages and many advantages over other woods, even over pine in some respects. It is, of course, a swamp wood and, untreated, decays rapidly, but when thoroughly treated with a

creosote oil mixture it resists decay perfectly, and the experience of somewhat over a year of very heavy travel in New York City has shown that it wears remarkably well; in the opinion of some, even better than pine. On account of its close and irregular grain it does not split as readily as pine and the waste in handling on the street is less. It exists in large quantities in the South, and inasmuch as it is not very useful for general lumber purposes the chances of getting it in large quantities at reasonable prices for a considerable period are good. Some 75 000 sq. yd. of this paving material have been manufactured and laid under the writer's supervision during the past year, and all of it is giving excellent results.

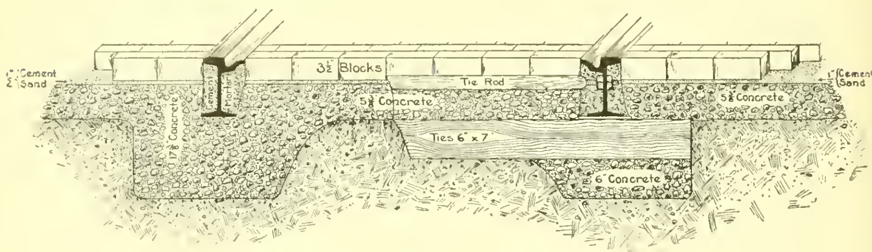
The perfect wood pavement would be one laid on a well-drained and compacted foundation, upon which is placed a suitable concrete base of such depth as to properly carry and distribute the loads which pass over the street, and having its upper surface brought to perfect crown and grade by the use of cement mortar, with blocks set in same while damp, or set upon same after hardening, in a coating of hot pitch, with all the blocks of a dense, tough and homogeneous wood, the pores of which are entirely filled with an antiseptic and waterproof mixture to exclude water. It should be laid with the blocks driven as tightly together as possible, and the joints filled with clean fine sand, cement grout or pitch, according to circumstances, all the blocks being cut to exactly uniform depth so that the surface of the street is perfectly even. Such a pavement, if not cut to pieces by public-service corporations and by trenches for sewer and water pipes, should give, under the heaviest travel, a life of from ten to fifteen years, with a rapidly increasing life as the character and amount of the travel becomes less destructive. It has been our effort to arrive at these conditions, and it should be a source of satisfaction to American engineers that the city engineer of one of the largest cities in the United States, after spending three months abroad last summer, devoting his entire time to the study of foreign pavements, should have reported upon his return that he saw no wood pavements anywhere abroad which were superior to those laid in his own city.

## DISCUSSION.

Mr. Arthur L. Plimpton. — As, at the time of the excursion to-day to Washington Street, Boston, the track work was covered up, I thought it would be of interest to show just what the construction was, and I had this cross-section prepared.

You will note that the rails are supported on the usual tie construction, ties being 2.5 ft. on centers, which in turn are supported in and on a continuous concrete beam extending 6 in. below the bottom of the ties, and about 5.5 in. above them, giving a total thickness of about 17.5 in. These beams are connected by an arch of concrete, which gives about 5.5 in. of concrete base in the middle for the wooden block pavement.

Previous experience on Beacon Street, where wooden blocks were laid in 1901, showed the importance of doing the work in such manner as to prevent water from working down at the side of the rail, which, when followed by freezing weather, will cause the blocks to heave up. In laying the tracks on Washington Street, therefore, it was decided to plaster with cement mortar next the rail its entire height just before putting in the concrete, which insured intimate contact between the concrete




Washington Street, Boston Elevated Ry., Surface Lines.

and the rail, so that when done there were no voids left in which water could accumulate. In the work recently done of relaying the tracks on Beacon Street with wooden block pavement the blocks themselves were laid on a layer of cement mortar and the joints filled with cement grout.

Cars were not run on the tracks on either Washington or Beacon Street until the concrete had been in place for ten days.

The whole aim in this form of track construction is to eliminate all movement of the rail under passing cars as far as possible, and in some recent work in connection with brick pavement a form of screw has been used instead of the usual track spike which, with its vastly greater holding power, will certainly help a great deal to prevent movement of the rails; and if the results justify the added cost, it will probably be adopted instead of the spike in future work in connection with expensive forms of pavement.

[Note. Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk St., Boston, by February 1, 1907, for publication in a subsequent number of the Journal.]

## OBITUARY.

### Charles Paine.

HONORARY MEMBER OF THE CIVIL ENGINEERS' CLUB OF CLEVELAND.

CHARLES PAINE, veteran railroad manager, born in New Hampshire, 1830, died at Tenafly, N. J., July, 1906. This interval of life, prolonged beyond the usual span, represents a busy, well-rounded career of railroad service.

He began as a youth of fifteen on the Vermont Central Railroad, and at seventy we find him assuming the duties of general manager of the Panama railroad. In 1858 he became a superintendent of the Michigan Southern and Northern Indiana lines, and in 1864, chief engineer. In 1872 he became general superintendent of the Lake Shore and Michigan Southern Railroad.

It was during the twenty-three years of his connection with the Lake Shore properties that he established a wide reputation as an administrative officer of exceptional ability. He left Cleveland in 1881 to take charge of the construction of the New York, West Shore & Buffalo Railroad, and remained there until after its completion in 1884, when he spent a year studying railroads in Europe. He was for a year second vice-president of the Erie, and then accepted the vice-presidency of the Philadelphia Company, which owned the natural gas properties around Pittsburg, and he held that position five years. The years 1891 to 1899 were devoted to private practice as a consulting engineer. In 1899 he was made general manager of the Panama railroad. He was a past president of the American Society of Civil Engineers, an honorary member of the Western Society of Engineers and of the Civil Engineers' Club of Cleveland, and a member of the American Society of Mechanical Engineers and of the Century Club of New York.

Although his later years were largely occupied by administrative duties, he never forgot his engineering training, and as leisure permitted wrote freely on railroad subjects. The viewpoint was that of a veteran engineer, and the series of papers which were later incorporated into his popular book, "The Elements of Railroading," were not only instructive, but written in an easy and entertaining style.

Mr. Paine was a successful administrator of railroad properties. He was trusted by his capitalists, maintained discipline and efficiency without provoking antagonism, and was diplomatic in his attitude toward the public. Like many men of

large affairs, he was not averse, on occasion, to looking after details. An instance in point of his thoroughness is related by Mr. Burgess, who says that at one time he went down the line with Mr. Paine. Upon crossing a track the latter made the remark, "I never step on to a track but that I immediately step off again. A simple thing, but I know of some poor fellows who, if they had followed this rule, might be alive to-day."

He resided in Cleveland many years, and, when the matter of forming an engineers' club was first considered, one of the serious problems was to select a suitable president. It was a most fortunate circumstance that the name of Charles Paine was suggested and found instant favor. The only drawback was the fear that it would be regarded as something of a presumption to ask him to take it, especially as the club was making a very modest beginning. No sooner, however, were our purposes made known to him than he entered into the project with a heartiness and enthusiasm that was as gratifying as unexpected. It was no perfunctory acceptance, but was cheerful and gracious, and ever after during his short remaining residence in the city he made it his business not merely to be our leader, but to be for us and to be one of us. The first formal meeting was held March 13, 1880. There had been misgiving and doubt as to what the movement might amount to, when the engineers of Cleveland, many of them utter strangers to each other, met in a body for the first time. When, however, Mr. Paine took the chair and in a dignified address gave eloquent expression of the dignity and importance of our calling, we began to realize that something might be accomplished by better acquaintance and concentration, and no one present then, or at subsequent meetings over which he presided, will forget the real interest he took in the work of the club, or the singular charm of his presence and manner. We felt that he had a genuine interest in every engineer, every young one especially.

We have appreciated and have felt an interest in his wide fame, in the many high positions he has filled with ability, grace and honor. We feel it a duty and a privilege to testify that when this society had its beginning, it was favored with his useful and kindly services and the impetus of his name.

WALTER P. RICE,
C. H. BURGESS,
HOSEA PAUL,
*Committee.*

# ASSOCIATION OF ENGINEERING SOCIETIES.

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## A STUDY OF THE EFFECT OF NEW ORLEANS CANAL WATERS ON CRAB LIFE.

BY R. M. REDDING.

[Read before the Louisiana Engineering Society, October 8, 1906.]*

LAST summer I sought an explanation for the abnormal mortality among the fish and crabs of Lake Pontchartrain. Believing this question of some general interest, I wish to present to you to-night the results of this study.

In as much as I was interested only in finding the cause of this abnormal mortality, I did not make an exhaustive examination along every line, but confined my study of the various canals to the possible and probable waste products emptying into that particular canal. In following out this line I examined each canal emptying into the lake for free acids and alkalies, phenols, cresols, naphthols and other tar products, sulphates, chlorides, and other probable mineral salts. The result of this line of work, covering some weeks, was *nil*, so I shall go into no detail on this line.

Since no deleterious substance of a mineral nature was detected in quantities to affect, it was an evident conclusion that the death of the crabs was due to some other cause. This belief was strengthened by the fact that the canals receiving the most waste from factory sources were not the most destructive to crab life. Further, that the two most destructive, Bayou Lauria and Seventeenth Street, are several miles apart, the former receiving little, if any, sewage.

The second line of study which I took up was suggested by the peculiar action of crabs in the canals. Agitation, increased

* Also read before the Louisiana Chemical Society.

respiration, attempts to remain at the surface and desire to get out of the water, led me to think that perhaps the water lacked oxygen.

As part of the evidence on which I shall later draw my conclusion, I wish to quote from S. Rideal ("Sewage and Bacterial Purification of Sewage"), showing the chemical process and steps in the oxidation of organic matter in sewage. "The oxidation of organic matter under favorable conditions of temperature has four stages, as shown in the accompanying table, the initial change occurring rapidly, using up the free oxygen in the water, after which the succeeding changes take place more slowly through the agency of enzymes."

Order of Change.

| | Substance Dealt With. | Characteristic Product. |
|---|---|---|
| *Initial.* | | |
| Transient aërobic changes by free oxygen in water, rapidly passing. | Urea, $NH_3$ and other easily decomposable bodies. | |
| *First Stage.* | | |
| Anaërobic liquefaction and hydrolytic changes. | Albuminous matter, cellulose and fiber, fats. | Soluble nitrogenous compounds, phenol derivatives, gases, $NH_3$. |
| *Second Stage.* | | |
| Semi-anaërobic; breaking down of the intermediate dissolved bodies. | Amido compounds, fatty acids, dissolved residues, phenolic bodies. | $NH_3$, nitrites, gases. |
| *Third Stage.* | | |
| Complete aëration and nitrification. | $NH_3$, and carbonaceous residues. | $CO_2$, $H_2O$ and nitrates. |

Also from J. H. Long (Journ. Am. Chem. Soc., January, 1890).

Long studied the oxidation of highly charged waters in the Illinois River for a distance of 160 miles. He found that the water rapidly lost its free oxygen, and that nitrates as indicative of the final stages of oxidation did not appear for many miles.

That sewage does not quickly pass through the intermediate stages to the point of re-aëration was demonstrated by Fowler, of Manchester, England.

He experimented on chemically precipitated sewage and got results as follows:

| Where Air Passed over Surface. | | Air Drawn through Liquid. | |
|---|---|---|---|
| Hours Exposed. | Oxygen-Consuming Power per Liter in Grams. | Hours Exposed. | Oxygen-Consuming Power per Liter in Grams. |
| 0 | 2.52 | 0 | 2.00 |
| 21 | 2.58 | 4 | 2.08 |
| 27 | 2.57 | 6 | 2.00 |
| 72 | 1.44 | 23 | 1.62 |
| 95 | 1.26 | 27 | 1.50 |
| 100 | 1.21 | 47 | 1.31 |
| 117 | 1.16 | 51 | 1.20 |
| 141 | 0.80 | 71 | 0.90 |
| | | 95 | 0.51 |

The work of these men demonstrated that water heavily contaminated is in a more or less oxygen-free state, and remains so until the stage of re-aëration is reached, unless greatly diluted with oxygen-carrying water.

With these facts in mind I wish now to give you the conditions found existing in the canals of New Orleans.

In presenting the results of these examinations I have used two standards — aërated distilled water and Lake Pontchartrain water.

| | Cu. Cm. per Liter. |
|---|---|
| Aërated water, distilled, at 86 degrees fahr: | |
| Dissolved oxygen | 5.42 |
| Required oxygen | 0.00 |
| (Dissolved oxygen at 86 degrees, according to Roscoe and Lunt, 5.43) | |
| Lake Pontchartrain: | |
| Sample taken July 5, 1905, one mile off Southern Yacht Club. | |
| Dissolved oxygen | 4.38 |
| Required oxygen | 3.40 |
| (Leed's standard for American river waters is 3.5 cu. cm. to 4.7 cu. cm.) | |
| Orleans Canal: | |
| Sample taken July 12, 1905. | |
| Conditions: Weather settled. Canal carrying average sewage. | |
| Dissolved oxygen | 2.94 |
| Required oxygen | 13.63 |
| Seventeenth Street (Bucktown): | |
| Sample taken July 7, 1905. | |
| Condition: Water heavily charged. Much evolution of gas. No evidence of crabs or fish. Crabs killed in cars in this canal in morning of this date. Dead crabs in evidence. | |
| Dissolved oxygen | 1.94 |
| Required oxygen | 12.00 |

| | Cu. Cm. per Liter. |
|---|---|
| **Bayou Lauria:** | |
| Sample taken July 12, 1905. | |
| Condition: Water almost black with suspended matter. Free bubbling of gases. Much evidence of dead crabs and fish. | |
| Dissolved oxygen | 0.00 |
| Required oxygen | 16.24 |
| **Broad Street Canal:** | |
| Sample taken July 14, 1905. | |
| Condition: Fair. Water low in canal. | |
| Dissolved oxygen | 1.15 |
| Required oxygen | 32.33 |
| **Gutter Water:** | |
| Sample taken July 14, 1905. | |
| Condition: Bad. Heavily charged with organic matter. | |
| Dissolved oxygen | 0.00 |
| Required oxygen | 63.70 |
| **Water from St. Louis Pumping Station:** | |
| Sample taken July 24, 1905. | |
| Condition: Bad. Water at temperature 97 degrees fahr. Much organic matter and excessive evolution of gas. | |
| Dissolved oxygen | 0.00 |
| Required oxygen | 46.88 |

On July 25 I collected a sample of gas from this canal and analyzed same.

ANALYSIS.

| | Per Cent. |
|---|---|
| $CO_2$, etc. | 1.20 |
| $CH_4$ | 88.92 |
| H | 0.00 |
| N | 9.88 |
| | 100.00 |

| | Dissolved Oxygen. | | | Required Oxygen. | |
|---|---|---|---|---|---|
| | Cu. Cm. per Liter. | Per Cent. of Aërated Distilled Water Value. | Per Cent. of Lake Water Value. | Cu. Cm. per Liter. | Per Cent. of Lake Water Value. |
| Aërated distilled water | 5.42 | 100.00 | 123.74 | ..... | ..... |
| Lake Pontchartrain | 4.38 | 80.81 | 100.00 | 3.40 | 100.0 |
| Orleans | 2.94 | 54.24 | 67.12 | 13.63 | 400.9 |
| Seventeenth Street | 1.94 | 35.79 | 44.29 | 12.00 | 352.9 |
| Bayou Lauria | 0.00 | .... | .... | 16.24 | 477.6 |
| Gutter water: Perdido and S. Howard | 0.00 | .... | .... | 63.70 | 1 873.5 |
| St. Louis Pump. Station | 0.00 | .... | .... | 46.88 | 1 378.9 |
| Broad Street Canal | 1.15 | 21.25 | 26.25 | 32.33 | 950.9 |

In considering the above it should be borne in mind that these values are much in favor of the canals, since the samples tested were taken in a period of settled weather, and also within 15 in. of the surface, where aëration is greatest.

Yet under these favorable conditions, Seventeenth Street Canal represents a state in which crabs had died a few minutes previous to the taking of the sample of water. By testimony of fishermen the greatest mortality among the crabs is shortly after heavy rains, when the city refuse is swept down the canals. Mortality among the crabs caught by this rush is nearly 100 per cent.

This is what one would expect, since the sweep of the city sewage in large volumes fills the canals with sewage in the first and second states of decomposition, the state in which little free oxygen is found in the water.

Not satisfied with drawing a conclusion untested, I took a good clear water, expelled the air by boiling, allowed it to cool out of contact with air, and made up dilutions of various percentages of aëration. Using a vessel of about 12 or 15 liters capacity, with an arrangement for excluding air from the surface, I placed strong, vigorous crabs in different samples of partially aërated water with the following results:

In each case the crab showed immediate signs of distress, rapidly increasing respiration, with respiratory organs open to the limit and circulation of water increased by means of every appendage of the head and fore part of body.

*A*. In dilution of 20.81 per cent. normal, the first crab died in 40 min., the second in 45 min. Per cent. of normal aëration at end, 13.0 per cent.

*B*. In dilution of 18.40 per cent. normal, first crab died in 25 min., second in 100 min.

*C*. In dilution of 33.21 per cent., crab died in 35 min. Per cent. of normal aëration at end, 20.5 per cent.

*D*. In dilution of 38.47 per cent. normal aëration, crab died in 40 min. Per cent. of aëration at end, 33.10 per cent. normal.

In no case did a crab survive longer than 100 min., the average being 47.5 min.

Rideal, Long and Fowler demonstrated that heavily charged water undergoing purification contains but little free oxygen, and remains in this condition until the point of re-aëration is reached. The time required for this point to be reached is much greater than that required for sewage to travel from the city to the lake. Long followed the Illinois for a distance of 160 miles, and,

although the water was constantly being diluted, found the evidence of final stages only far down the river.

The conclusion logically follows that the death of the crabs is not due to poison directly injected into the canals, but is due to the absence of free oxygen in the water, assisted possibly by the presence of intermediate products of oxidation of organic matter. These conditions are brought about by the water in the gutters and canals being heavily charged with organic matter, which standing stagnant for days in the hot sun undergoes decomposition of organic matter, thereby denuding the water of its free oxygen.

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[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, 31 Milk Street, Boston, by February 15, 1907, for publication in a subsequent number of the JOURNAL.]

# IRRIGATION WORKS IN ARIZONA.

By C. L. Gates, Member of the Toledo Society of Engineers.

[Read before Society, April 13, 1906.]

The general subject of "reclamation," or reclaiming for agriculture ordinary arid lands by irrigation, a part of which subject this paper treats, may present but little interest to an audience in Ohio, but to the farmer or range man and resident of the great West and Southwest it is of vital importance; in fact, upon successful irrigation in that region depend the farmer's and stockman's very life and existence.

It was recently my fortune to travel through Arizona, that "land of promise and fulfillment," a very appropriate name given it by one of our prominent writers, a former Toledoan, in an article recently published in the *Pacific Monthly Magazine.* I refer to Mr. Elmer Whyte, formerly of the Toledo *Bee.* I may as well admit in the outset that my own idea of Arizona, at least the southwestern part of it, had always been of an arid, level waste or desert so hot in summer as to make it well nigh impossible for man to exist there; at best he would simply gradually shrivel up and be blown away or die of thirst. Instead, it is a land of sunshine and flowers, birds and fruitage, with many wooded areas, of untold wealth of minerals, of mountains of pineclad grandeur and canyons of eroded and awesome splendor, of water supplies and water power only waiting man's conservation, and of valleys whose silt and glacier-made soil lies hundreds of feet in depth, inviting the most profitable farming and fruit growing for ages to come.

I suppose every one in this intelligent audience of the Toledo Society of Engineers knows the climate in the semi-tropical territory of Arizona. It has its winter or rainy season, with occasional very light frosts during the months of December, January, February and March. Last winter it had a most unusual and almost continuous rainfall in January and February, but from April to November there is practically no rain, except that once in a great while some heavy thunderstorm may break loose in the mountainous country, and the otherwise dry creek beds then carry the water with destructive force.

As before mentioned, there is much rich soil in the level plains and valleys, waiting only for a reasonable regular supply of

moisture to transform these deserts into perpetual gardens. Some valleys particularly are wonderfully fertile. One of these is the Salt River Valley, in the center of which lies Phœnix, the capital of the territory of Arizona. The valley is some 60 miles long and perhaps 25 miles wide, and its inhabitants are convinced that it is the richest garden spot on earth. Irrigation is by no means an experiment in Salt River Valley, for irrigation was attempted and carried on there long ago, as is shown by the remains of canals and ditches leading from the river far out upon the plains, built ages before the white man came. With the advent of the emigrant and white settler, private enterprises of irrigation have been attempted in various localities of the United States, and the Salt River Valley of Arizona has had its water supply company; but it has been the almost universal result of the private irrigation enterprises in the West, from the lack of sufficient capital and the immensity of the undertakings, that failure came to them sooner or later. The works were generally of a temporary nature, fulfilling the promise only so long as average conditions existed. During the time of any unusual drought the water supply failed, and in periods of flood the dam would be washed out and destroyed, followed by financial failure to the water supply company as the usual natural result. Such was the experience of the Salt River Valley Canal and its water preservation and supply enterprises. A brush dam across Salt River some 22 miles above Phœnix, built below the mouth of the Verde River, was taken out by last year's flood, and with it came the failure of the Arizona Water Supply Company. But the passage of the National Irrigation Law, signed by the President June 17, 1902, and the carrying out of its measures brought permanent relief to these people.

The provisions of the Reclamation Law are as follows:

(1) A reclamation fund in the treasury of the United States consisting of the proceeds from the sales of public lands in the sixteen arid and semi-arid states and territories.

(2) A reclamation service in the United States Geological Survey to investigate and report on the irrigation projects for the approval of the Secretary of the Interior, who may authorize the construction and let contracts, providing the money is available in the fund.

(3) The return to the fund of the actual cost of each project by the sale of water rights, payments to be made in a series of instalments running over a period of ten years.

(4) The holding of public lands for actual settlers under the

Homestead Act in small farm units sufficient to support a family, no commutation to be permitted.

(5) The sale of water rights to private land owners, but not for more than 160 acres, making land monopoly impossible and forcing the division of large estates.

(6) The ultimate turning over to the people of the irrigation works, except the reservoirs, to be operated and managed by them under a system of home rule. The actual users of the water in ten years after its completion of the works will have repaid to the government the amount of its loan without interest. The money so returned may again and again be expended for other reclamation works.

So, by the middle of 1905, some $27 000 000 has been derived from the sale of public lands and appropriated for this work, and it is estimated that within the next three years at least $10 000,000 more will be received from the same source, and the object is to spend this money for reclamation where it will do the most good to the greatest number of people. The above amount, increasing every year as you see, will be the working capital for building reclamation works and transforming other deserts into rich farming lands; and we see the importance of it when we remember the enormous extent of the country embraced in the arid regions, — all of two fifths of the United States.

The reclamation work of the Salt River Valley has been one of the first undertakings of the kind under government control since the passage of the act of 1902; and while the great dam has not yet been built, in fact, the building of the dam proper had hardly been commenced during my visit to the site, yet great progress in accessory works has been made. The location of the site is across the river canyon some 75 miles above Phœnix, immediately below the mouth of Tonto Creek, at a point where the river is confined between solid rock walls 500 ft. or more in height above the river bed. Above the dam the valley opens out to some 2 to 5 miles in width between the bluffs, making an excellent natural storage reservoir. The dam as designed has the cross-section of an ordinary masonry gravity dam; that is, its base is wide and its mass great enough to resist overturning from the designed head of 210 ft. of water pressure. However, in general plan the structure is built on a curve of about 400 ft. radius, the skew backs of the arch abutting against the solid walls of the confining cliffs. It will be about 235 ft. long by 160 ft. wide at its lowest foundations, gradually lengthening as

it is built up between its abutments to a total length of 780 ft., and 16 ft. wide at top, with spillways 100 by 20 ft. deep cut out of the solid rock cliffs at each end. The total height of masonry from foundations will be 284 ft. Consider for a moment this great height, comparing it with our Nicholas Building. I learn that that building has a height of 200 ft. from level of sidewalk to roof cornice. This makes this dam some 84 ft., or about seven stories, higher. The estimated amount of masonry in the dam is 300 000 cu. yd. of uncoursed rubble work of sandstone taken from adjoining cliffs, and requiring about 240 000 bbl. of Portland cement in its construction.

The reservoir formed by this great barrier will be one of the largest artificial lakes in the world, 2 to 4 miles wide and some 27 miles long, that is, some 9 miles up Tonto Creek and 18 miles up Salt River. The village of Roosevelt, a thriving town of about 2 000 inhabitants, with electric lights, water works, schoolhouses, stores and churches, is located on a level bench some 30 ft. above water at the confluence of the two rivers, and it will be some 180 ft. to 200 ft. below water after the dam is built and serves its purpose. The capacity of the reservoir will be ten times greater than the Croton Reservoir, and it will contain more water than is stored by the Assouan Dam. It will contain 1 400 000 acre-feet, that is, it would cover that number of acres, or 2 200 sq. miles, one foot deep. The area of the reservoir is 15 000 acres and it drains a basin of 5 756 sq. miles; it is said to contain water enough to supply irrigation for four seasons.

The purpose of the reservoir is primarily to furnish storage to give a needed uniform supply of water during the dry season. A diversion tunnel, 10 by 13 ft., has been built through the bluffs at present low-water level, reaching from above the dam into the river bed below, and after the works are completed the water for irrigation purposes will be diverted through this tunnel and through the present narrow confined river channel for 44 miles and then be diverted through channels to the irrigable lands.

In connection with this dam an 8 by 8 ft. power canal, for most of its length lined with cement, has been built along and through the hills and across some intervening side canyons some 22 miles long, to a point below the dam to furnish the water and head for a power plant to be installed to supply some 5 000 h.p., which power is to be used to lift water for irrigation on mesas or plains on higher levels than the present irrigation canals could supply.

*Wagon Road.* The question of supplies of material, fuel, tools and machinery, as well as the commissary department for an army of laborers, was an important one to consider, for to reach the site there was but one narrow wagon road with heavy grades over the mountains, and about 40 miles long, to Globe, the nearest town of any importance and the terminus of a local railway branching from the main line of the Southern Pacific Railway, then the only available railroad for transportation. To reach the Sante Fé Railroad, a competing line, a wagon road was constructed 62 miles long to Mesa, 15 miles from Phœnix on Southern Pacific and Sante Fé Railroad, to the cost of which the municipalities of Phœnix, Tempe and Mesa contributed $75 000. The road was constructed by the government engineers and not by contract, and it is one of the most spectacular pieces of engineering in the West. For more than 40 miles it is in the canyon of the Salt River, many miles having been blasted from the precipitous walls. The day laborers were mostly Apache Indians, remnants of Geronimo's band. The road opens up a new region of beautiful and imposing scenery, and when the great dam is completed the Tonto Reservoir and the Roosevelt Dam will surely attract the transcontinental tourist and visitor.

*Cement Plant.* In the construction of the dam and accessories, some 240 000 bbl. of cement are required. The question of cement was not the least of the problems that had to be taken care of by the engineers. The isolation of the dam site and a tendency on the part of cement manufacturers to place as high a value on their product as they thought it would bear, offered a very serious problem. The first bids on Portland cement were $9 per bbl. delivered at the site, making this item over $2 000 000. Then it was that the geological engineer came into play and showed his usefulness. A reconnaisance of the ground disclosed the fact that a ledge of limestone free from magnesia outcropped just above the dam site, while hills of clay, suitable for cement, were within a short distance of it, only a few hundred feet. Notwithstanding the vigorous protests of cement manufacturers and their offer of cement at about half their former bids, the Secretary of the Interior authorized the building of a cement mill. This mill has been in successful operation for several months and is now turning out about 100 bbl. of first-class Portland cement every day, and will, after complete installing of power plant, make over three times the amount per day, and save in the cost of the dam more than a

million dollars on the price offered by the cement trust. After passing through this small but quite modern cement mill I thought this an excellent opportunity to pick up more knowledge on the subject, and I had at first intended to make this a paper on modern American practice of Portland cement manufacture, but I find that to go into details now would be beyond the limits of this paper, so will simply say that a very fine product of slow-setting cement is being made, excellently fitted for the purposes intended.

I will close by giving the government engineers' estimated cost of the dam and its accessories. I have had access only to the earlier estimate, which gives approximate cost about \$2 000 000, but I am told that already nearly \$2 000 000 have been spent on the wagon road, cement mill and power canal; its several tunnels and siphons and the dam proper have hardly been begun, so the total cost will reach nearer \$4 000 000, the government, I understand, having offered the old Arizona Canal and Water Supply Company for canals, old water rights, etc., about \$304 000.

Estimated Cost Salt River Storage Dam at Roosevelt.

| | |
|---|---|
| Excavations for foundations and river diversion | \$50 000 |
| Cost of cement plant | 91 000 |
| 260 000 cu. yd. rubble masonry, exclusive power plant and cement, at \$3.50 | 910 000 |
| Power plant, power house and canal, complete | 188 360 |
| Manufacturing 200 000 bbl. cement at \$2.00 | 400 000 |
| Outlet tunnel | 31 450 |
| Gates and machinery | 11 600 |
| Outlet towers, shafts and houses | 9 000 |
| Viaduct across spillway | 26 000 |
| Roads and telephones | 15 000 |
| Engineering and contingencies | 259 860 |
| Damage to private lands | 42 000 |
| | \$2 034 270 |

Dam 40 ft. higher, with estimated capacity of 1 450 000 acre-feet, would cost approximately \$2 700 000.

[Note. — Discussion of this paper is invited, to be received by Fred. Brooks, 31 Milk Street, Boston, by February 15, 1907, for publication in a subsequent number of the Journal.]

## OBITUARY.

### Albert Henry Zeller.

Member of the Engineers' Club of St. Louis.

Albert Henry Zeller was born in St. Louis, January 20, 1867. He was the second son of William Zeller and Christine Haarstick-Zeller. His death occurred in St. Louis on the second day of November, 1906, at the age of thirty-nine years, after an illness of several months. He is survived by his mother, two brothers, William F. and Eugene C. Zeller, and one sister, Mrs. F. W. Frerichs of St. Louis.

When young Zeller was three years old his parents took him to Germany for a year, returning to this country in 1871. At this early age he developed a love for music and was allowed to begin his studies on the violin. In later years, without permitting his love for music to encroach upon the time due his chosen profession, that of civil engineer, he devoted many of his leisure hours to the violin, to his own enjoyment and that of a few chosen friends. Zeller received his early education at the St. Louis public schools, attending the Peabody School at St. Louis from 1873 until 1878, when he was sent to a French school at Lausanne, Switzerland. He remained at Lausanne two years, taking a regular course, but devoting considerable time to the study of the French language, in which he became very proficient. In 1880 he returned to St. Louis and attended Smith Academy and later Washington University, graduating from the former in 1883 and from the latter, with the degree of Bachelor of Engineering, in 1887. He was particularly fond of mathematics and was ever ready to apply mathematical solutions to problems coming under his notice.

Zeller's first employment after graduation was as draftsman and assistant engineer, St. Louis, Iron Mountain & Southern Railway, at St. Louis until April, 1889. From April, 1889, until May, 1891, with the exception of a period from May to December, 1890, during which time he traveled in Europe, he was engaged as assistant engineer with the St. Louis Merchants Bridge Terminal Railway, St. Louis, Mr. Robert Moore, Chief Engineer. From May, 1891, to November, 1892, he was employed in the designing department of the Edge Moor Bridge Works, Wilmington, Del. From February to May, 1893, he was principal as-

sistant engineer, St. Louis Terminal Railway Association, in charge of erection of train shed at the new Union Station. In May, 1893, he was appointed engineer assistant to the president of the Board of Public Improvements at St. Louis, a position which he filled for four years with much credit to himself and much profit to the city of St. Louis. Robert McMath, who was president of the Board of Public Improvements at the time, states, writing of Zeller: "He declined reappointment for another term, intending to go to Europe for a long stay. I was sorry to lose him, for he was worthy of confidence, and our relations were wholly pleasant to both, as also with all who came in contact with him." Resigning from the service of the city in 1897, he went abroad for two years, and returning, opened an office at St. Louis for the general practice of his profession, at which work he was engaged at the time of his death. For some years past, however, he had devoted much of his time to managing the estate of his family and, though he kept abreast of the time in his profession and was well posted on the engineering problems of the day, he did not engage in extensive practice.

His services in behalf of the Engineers' Club of St. Louis were marked by the same painstaking care and thoroughness of detail which he applied to every problem intrusted to him. He was naturally of a modest and retiring disposition, never inclined to push himself to the front, but his ability and trustworthiness were recognized by the Engineers' Club in frequent appointments for committee work. When the Club moved to its present quarters a few years ago, Zeller was appointed on the committee on quarters. His work as a member of the committee was untiring and to him, more than any one else, the Club is indebted for the pleasant arrangement of the quarters which we now enjoy.

Zeller had traveled much, having visited Europe no less than five times. He was a man of broad mind and sound judgment, and without guile or deceit. To know him was to admire him. Justice and truth and gentleness were embodied in his every act and thought. His friends thought of him as one on whom they could depend for assistance in every good cause, and, if need be, for such sacrifices as friendship calls for. In his untimely death the engineering profession has lost a member whose life can ill be spared. The community in which he lived, the associates who enjoyed his friendship, will remember him and continue to feel the influence of his thought and his life, and he will not have lived in vain.

It seems but proper to add the following testimonial by Mr. William Chauvenet:

"How pleasant it is, after all, to speak of one whose memory must ever be a sweet one and whose life as we recall it will ever help to make us better men. It was his gentleness in all his relationships, and his justice in all dealings with men, that most impressed me. He was strong to see the right and fitting thing to be done in any emergency, and his clear vision was ever helpful to his friends. His command of himself in all positions, and the absence of any tinge of severity in the exhibition of such command, was one of his most noted characteristics. Ever considerate of others, he nevertheless made you feel that he was somehow under obligations to the one he was helping, and this mark of the true gentleman was one of his charms as a companion and as a friend. Of his own fortunes, whether good or bad, he never spoke, while his ever active interest in the good fortunes of others, and his sure sympathy in times of loss, made him one whom we naturally sought out whenever the clouds hung low. Assuming nothing, yet was his judgment sound, and in all his relationships with men, and especially with his comrades, nothing could disturb his sweetness. I know I am naming the characteristics of a rare man and one more associated with the old school than with our aggressive and unconventional times, yet such was my friend and dear companion. He is to me alive and often present in our midst, because his qualities partook of those things which do not die but live on, safe within the hearts of those who had learned to love him while here."

Edward Flad.
R. H. Fernald.
W. G. Brenneke.

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## Freeman Clarke Coffin.

Member of the Boston Society of Civil Engineers.

Freeman Clarke Coffin was born in Boston on September 14, 1856, the son of Alonzo King and Mary E. Coffin. He received his early training at the public schools of Patten, Me., to which place his family moved two years after his birth. At the age of fourteen years, when the support of the family fell upon him, he became a clerk in a country store. A year or two later he began the manufacture of furniture in a small way, and in

the course of the next ten years bought an old planing mill and water privilege in Patten, and built up the largest furniture manufacturing establishment in the community.

Feeling that this business did not offer him a satisfactory outlook, he returned to Boston at the age of twenty-six, and became a pattern maker at the works of the Coffin Valve Company, then operated by his uncle, Mr. Z. E. Coffin. There he remained two years, until 1884, when he entered the employ of Mr. M. M. Tidd, of Boston, as one of his engineering assistants. Mr. Tidd was at that time one of the best known hydraulic engineers in New England, devoting himself largely to water-works construction. For ten years Mr. Coffin remained with Mr. Tidd, during the latter eight of which he was Mr. Tidd's principal assistant. This was, perhaps, the formative period in Mr. Coffin's career, for he was intensely interested in his new employment and spent all his leisure hours in making good the lack of early technical training and in perfecting himself for the broader field which he was to enter upon leaving Mr. Tidd's office.

On January 1, 1894, he opened his own office in Boston, and, in 1905, took into partnership his principal assistant, Mr. Lewis D. Thorpe.

During the last twelve years of his life Mr. Coffin designed and supervised the construction of many water and sewerage works, and reported upon many engineering projects, the most important of which were the water works at Cambridge, Haverhill, Ipswich, Merrimac, Walpole, Mass.; Bar Harbor, and Seal Harbor, Me.; Walpole, N. H., and Windsor and Proctor, Vt., and the sewerage works at Charlottetown, P. E. I.; Marion, Mass.; Proctor, Vt.; Chatham, N. B., and Truro, N. S.

As an expert in water-works valuation and water power cases, Mr. Coffin's opinion was often sought. He acted as arbitrator in the valuation case at Bartlett, N. H., and as referee in the water power case at Hinsdale, N. H. He gave testimony in the Spot Pond, Haverhill, West Springfield and Athol cases in Mass.; at Newmarket and North Conway, N. H.; at Gardiner, Waterville and Brunswick, Me.; and at Ithaca, N. Y. He also made report and valuation upon the works at Baton Rouge, La.; Barre, Vt.; Claremont, N. H.; Swampscott, Revere and Amesbury, Mass., in all of which cases, excepting Baton Rouge, his report formed the basis of settlement with the water companies located at those places, without appeal to the courts. He testified in suits for the diversion of water at Attleboro,

Taunton and Waltham, Mass.; Woonsocket, R. I.; Wolfboro, N. H., and at Bar Harbor, Me.

Mr. Coffin was a member of the American Society of Civil Engineers, the Boston Society of Civil Engineers, the New England Water Works Association and the Canadian Society of Civil Engineers. The formation of the Sanitary Section of the Boston Society of Civil Engineers was due to his inspiration, as was in no small degree its success.

In spite of the demands of his professional practice he found time to take a hearty and active interest in the work of these societies, as is shown by the admirable technical papers and discussions presented by him before them. He contributed valuable discussions to papers upon the "Financial Management of Water Works," and "The Valuation of Water Works," published in the *Transactions of the American Society of Civil Engineers*, and presented a paper upon the former subject before the New England Water Works Association. He also contributed important papers before the latter association upon "Standpipes and Their Design," "Friction in Several Pumping Mains," "Corrosion of Pipes," "Application of Gas, Gasoline and Oil Engines to Pumping Machinery," "Covered Reservoirs and Their Design," and others of lesser importance. His paper upon "A Few Notes on Cast Iron Pipe," was the forerunner of the general discussion in engineering societies upon standard specifications for cast-iron water pipe, and led to his appointment as chairman of the committee of the New England Water Works Association, which drafted the "Standard Specifications for Cast-Iron Pipe and Special Castings," now coming into general use. He had also served for several years in the same society as chairman of a special committee upon "Meter Rates." In 1897 Mr. Coffin published his handbook of "Graphical Solution of Hydraulic Problems," which has won very favorable comment, and passed through two editions.

Mr. Coffin took an active interest in public questions of the day, and frequently took part in discussions at the Twentieth Century Club, of which he was a member.

At the time of his death Mr. Coffin was a vice-president of the Boston Society of Civil Engineers, chairman of its Sanitary Section, and had been nominated for vice-president of the New England Water Works Association.

He died at his home in West Medford on November 11, 1906, and is survived by his widow and four sons.

Without early technical training, and though he took up

engineering work late in life he attained in a comparatively short professional career to the foremost rank of the civil engineers of New England. Mr. Coffin was a fine example, not only of the self-made but of the well-made man. He was simple in his tastes and daily life and a firm believer in the gospel of work, broad in his point of view, and courageous but courteous in action. Honest, fair-minded and generous, he won for himself the respect of all and the admiration and affection of the younger men in the profession, in whom he always took a warm and friendly interest. In his death the profession has suffered the loss of a strong and independent thinker, the community of an upright and public-spirited man.

LEONARD METCALF,<br>
WILLIAM S. JOHNSON,<br>
*Committee.*

# Association of Engineering Societies.

Vol. XXXVI. JANUARY, 1906. No. 1.

## PROCEEDINGS.

### Engineers' Club of St. Louis.

St. Louis, December 6, 1905. — The 606th meeting of the Engineers' Club of St. Louis was called to order in the Club rooms, 3817 Olive Street, on Wednesday evening, December 6, 1905, at 8.15 P.M., President Flad presiding. Thirty-one members and four guests were present.

The minutes of the 605th meeting were read and approved.

The application of Mr. G. H. Elvis for membership in the Club was read and referred to the Executive Committee. Applications for membership from Mr. George B. Evans and Mr. Jacob D. von Maur were read and referred to the Executive Committee.

Nominations for officers of the Club for the ensuing year, in addition to those made by the Nominating Committee, were called for, but none were made.

The report of the Executive Committee, signed by the President, was read by the Secretary. It was ordered accepted and filed.

The report of the Secretary was read and ordered accepted and filed.

The report of the Librarian was read and ordered accepted and filed.

The report of the Treasurer was read. It was moved that it be referred to an auditing committee; motion amended by Mr. Layman to read that it be referred to an organized auditing company, for the purpose of securing not only an authoritative auditing, but suggestions for methods of keeping the accounts. Amended motion carried.

The report of the Entertainment Committee was read and ordered accepted and filed.

The report of the Board of Managers of the Journal was read and ordered accepted and filed.

Mr. Hans Toensfeldt, for the Committee on Regulation for Construction in Reinforced Concrete in St. Louis, reported progress and asked for further time. On motion the committee was ordered continued.

Mr. C. D. Purdon showed a series of photographs of a banana cooling plant installed by the Frisco Railroad at Springfield, Mo. The object of the plant is to cool the fruit from a temperature of about 78° fahr. to about 55° fahr., at the rate of about 0.75° per hour. Several of those present asked a number of questions about the operation of the plant.

It was moved by Mr. Brenneke that a sinking fund be established by the Club for the purpose of ultimately erecting a building for the Club headquarters. After some discussion, it was moved by Mr. Pfeifer that a committee of five be appointed to investigate the feasibility of such action and to report to the Club. The motion was amended to read that the new Executive Committee be charged with this duty. Amended motion carried.

Adjourned.

A. S. Langsdorf, *Secretary pro tem.*

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607th Meeting, St. Louis, December 20, 1905. — The annual dinner of the Club was held at Hotel Jefferson, Twelfth and Locust streets, Wednesday evening, December 20, 1905. President Flad presided. Thirty-seven members and twenty-one guests were present.

After an excellent dinner, President Flad called the meeting to order and announced the election of the following officers for the year 1906:

President — W. A. Layman.

Vice-President — E. R. Fish.

Secretary — R. H. Fernald.

Treasurer — E. E. Wall.

Directors — C. A. Moreno and C. D. Purdon.

Members of the Board of Managers of the Association of Engineering Societies — A. P. Greensfelder, H. C. Toensfeldt.

President Flad then introduced the new President, Mr. W. A. Layman, as toastmaster for the evening. After brief introductory remarks the toastmaster called upon the retiring President for his address, after which the following list of toasts was responded to:

"The Engineer's Opinion of Himself," Robert Moore; "The Engineer in Print," William Marion Reedy; "The Engineer in Public Life," Andrew J. O'Reilly; "The Engineer in Trouble," Frederick W. Lehmann; "The Engineer and the Architect," William B. Ittner.

The toastmaster then called upon Prof. C. M. Woodward to respond to "The Infant Engineer," after which the meeting adjourned promptly at midnight.

R. H Fernald, *Secretary.*

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St. Louis, January 3, 1906. — The Engineers' Club of St. Louis held its 608th meeting at the Club rooms, 3817 Olive Street, Wednesday evening, January 3, 1906. President Layman presided. There were present twenty-three members and seven guests.

The minutes of the 606th and 607th meetings were read and approved. The minutes of the 397th, 398th and 399th meetings of the Executive Committee were read.

Applications for membership from the following gentlemen were presented and referred to the Executive Committee: William Alfred Baehr, John Robert Cullinane, Frank W. Combs, Edward G. Cowdery, C. Wellington Koiner, Samuel Carson McCormack, Arthur S. Partridge, Henry F. Rosenow, Arthur Henry Timmerman, Guy Anderson Watkins.

The following were elected to membership in the Club: George Harvey Elvis, George B. Evans, F. H. Pearson, Jacob D. von Maur.

The resolution of the Executive Committee relating to a committee of three on expansion of membership (see minutes of 399th meeting of Executive Committee) was presented to the Club for action. Upon motion of the Secretary the Club approved the resolution and authorized the President to appoint the committee. The President appointed Mr. A. H. Zeller, chairman, Mr. Richard McCulloch and Gerard Swope.

Upon motion of Mr. Greensfelder a vote of thanks was extended to Messrs. Baehr, Von Maur and Evans, of the Laclede Gas Light Company, for the very cordial reception extended to the members of the Engineers' Club upon the occasion of the recent visit of the Club to the plant of the above-named company.

An excellent paper was presented by Mr. R. E. Einstein, upon "Frogs and Switches." The paper was discussed by Messrs. Pfeifer, Greensfelder, Phillips and Flad.

The President then introduced Mr. Day and Mr. Lauer, of Philadelphia, experts on factory conditions. Mr. Day gave a very interesting outline of the work in which they are engaged, explaining its origin, necessity and rapid development.

Adjourned.

R. H. FERNALD, *Secretary.*

## Civil Engineers' Club of Cleveland.

REGULAR MEETING, DECEMBER 12, 1905, at the Club rooms, called to order by the President at 8.15 P.M. Present, thirty members.

Minutes of preceding meeting read and approved.

The tellers, Mr. Lane and Mr. Hanlon, reported the election to active membership of Louis A. Corlett, Philo A. Orton, George H. Rose and Adolphus E. Sprackling.

Owing to the illness of General Smith, the paper scheduled for this meeting could not be given, and in lieu of it the President called for a discussion of some current topic.

Mr. Tinker presented the subject of the present law governing the clearance of overhead railroad bridges, citing the case of the new bridge now being constructed over the New York, Chicago & St. Louis Railroad, at Detroit Street, in this city, in which the clearance is only a little over 16 ft., the small head room in this case not only endangering the lives of employees, but causing the cutting down in height of some of the rolling stock.

This subject was discussed at length by Messrs. Nelles, Green, Lane, Hanlon and others. On motion of Mr. Lane, a committee of three (Messrs. Hanlon, Hoffman and Fox) was appointed by the President to investigate the present law on the subject and report to the Club what changes in it might be desirable.

President Green presented the subject of the making of concrete at a temperature of 25° fahr., which was discussed by Messrs. Herman, Nelles, Tinker, Lane and others.

Adjourned.

JOE C. BEARDSLEY, *Secretary.*

Regular Meeting, January 9, 1906, at the Club rooms, called to order by the President at 8.15 p.m. Present, forty-two members and visitors.

Minutes of preceding meeting read and approved.

The President announced the appointment of Mr. Rice to be chairman of the Committee on Water Pollution in place of Colonel Kingman, at the request of the latter.

The President also announced the appointment of Messrs. Bidwell, G. A. Hyde and Hinchman as a Committee on Resolutions on the death of Mr. William Chisholm, on December 6 last. Mr. Bidwell presented the appended resolutions from this committee. On motion of Mr. Lane, they were unanimously adopted.

Nominations for the Nominating Committee being called for, Mr. Henderer placed in nomination the last seven past presidents, who are eligible, viz.: Dr. Howe, Messrs. Ritchie and Osborn, General Smith and Messrs. Hopkinson, Benjamin and Wellman. On motion of Mr. Lane, nominations were closed and the Secretary instructed to cast the ballot of the Club for the nominees above named.

The paper of the evening, "The Use of Suction Gas Producers for Power Purposes," was then given by Mr. N. T. Harrington, of the Olds Gasoline Engine Works, of Lansing, Mich. A general discussion followed the reading of this very interesting paper, many members taking part.

Adjourned.

Joe C. Beardsley, *Secretary.*

## Boston Society of Civil Engineers.

Boston, Mass., December 20, 1905. — A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, Boston, at 8 o'clock p.m. President John W. Ellis in the chair; one hundred and thirty-four members and visitors present.

The record of the last meeting was read and approved.

Messrs. David A. Ambrose and William V. Moses were elected members of the Society.

Mr. George S. Rice gave a very interesting talk on the "Construction of the New York Subway." The talk was illustrated by a large number of lantern slides.

Adjourned.

S. E. Tinkham, *Secretary.*

Boston, January 24, 1906. — A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, Boston, at 7.45 o'clock p.m. President John W. Ellis in the chair; ninety-six members and visitors present.

The record of the last meeting was read and approved.

Messrs. Carl P. Abbott, Paul A. Babcock, John Campbell, Edwin W. Ellis and Frank C. Kimball were elected members of the Society.

On motion of Mr. C. W. Sherman, the President was requested to appoint a committee of three to retire and report to the meeting the names of five members to serve as a committee to nominate officers for the ensuing year. The President appointed as that committee, Messrs.

C. W. Sherman, A. H. French and G. A. King. Later in the meeting this committee reported the following names as members of the Nominating Committee and they were elected unanimously: Messrs. J. Parker Snow, I. T. Farnham, F. A. Barbour, A. T. Safford and C. M. Saville.

On motion of Mr. Adams, the President was requested to appoint the usual committee to make arrangements for the annual dinner of the Society. The President named as that committee Mr. Henry Manley.

On motion of the Chairman of the Excursion Committee, the thanks of the Society were voted to the following officers of the Revere Rubber Works, for courtesies extended to members of the Society this afternoon, on the occasion of the visit to the works of the company: C. P. Converse, president; E. S. Williams, general manager; Frank Veazie, superintendent; and J. S. Patterson, assistant superintendent.

The literary exercises of the evening consisted of two very interesting talks, fully illustrated by lantern slides. The first by Prof. L. P. Kinnicutt, entitled, "An Informal Talk about a Visit in 1905 to the Percolating Sewage Filters at Birmingham and the Contact Beds at Manchester, England," and the second by Prof. William T. Sedgwick, of the Massachusetts Institute of Technology, on "Observations of a Sanitarian in Sicily and Other Parts of Southern Europe."

After passing a vote of thanks to Professor Sedgwick, who was not a member of the Society, the meeting adjourned.

S. E. TINKHAM, *Secretary.*

## Civil Engineers' Society of St. Paul.

ST. PAUL, MINN., JANUARY 8, 1906. — The twenty-third annual meeting of the Civil Engineers' Society of St Paul was held in Parlor 117 at the Merchants' Hotel at 6.30 P.M.

Seventeen members and five visitors in attendance.

President Starkey in the chair.

The minutes of previous meeting were read and approved.

The reports of the Secretary, Treasurer and Librarian were read and accepted.

Mr. Oscar Claussen was elected president and Mr. James D. DuShane vice-president. The remaining officers were reelected without the formality of the individual ballot.

Upon taking the chair, after a few appropriate remarks, President Claussen appointed Mr. Starkey and Mr. Munster to audit the Treasurer's accounts, and the Secretary was instructed to advise Mr. Charles Warren Hunt, secretary, that the members of the American Society of Civil Engineers would be cordially welcomed to our library at any time, and to our meetings, which are regularly held on the second Monday of each month, June to September inclusive excepted.

At 7.20 the meeting adjourned to the dining room. After dinner, the subjects of river improvement, good roads, etc., were discussed, the following gentlemen offering apt and interesting remarks: H. H. Harrison, Captain Powell, Major DuShane, C. A. Forbes, Professor Hoag, Oliver Crosby, E. P. Burch and F. W. Cappelen

Adjourned at 9.30 P.M.

C. L. ANNAN, *Secretary.*

## Technical Society of the Pacific Coast.

San Francisco, December 1, 1905. — A meeting was held for the purpose of electing a nominating committee to prepare a ticket of officers for the ensuing year.

President Dickie called the meeting to order, and the following were elected by the members present: Stetson G. Hindes, chairman; W. J. Cuthbertson, Edward F. Haas, S. C. Irving, Adolf Lietz.

The Secretary was instructed to inform these members of their election, and to request the chairman to call a meeting for the purpose set forth.

Meeting thereupon adjourned.

Otto von Geldern, *Secretary.*

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Autumnal Meeting, San Francisco, December 14, 1905. — Called to order on Thursday evening, December 14, 1905, at 8 o'clock, by President Dickie, who welcomed the members and guests in the name of the Society.

The paper of the evening was written by Mr. Edward T. Hewitt, who was not present (it was read by his brother, Mr. William A. Hewitt), and treated of the "Modern Polytechnic High School," describing in detail the construction and arrangement of the Los Angeles Polytechnic School, with which Mr. Hewitt is directly connected. Plans and sections of the buildings were laid before the members, who discussed the subject in its various phases at some length; after which the meeting adjourned.

Otto von Geldern, *Secretary.*

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Autumnal Meeting, Friday, December 15, 1905. Afternoon Session. — Called to order at 2 o'clock by President Dickie. Mr. Frank P. Medina read a paper entitled, "Property in Invention," which was discussed, after which the meeting adjourned until 8 o'clock p.m.

Evening Session. — Called to order at 8 o'clock, by President Dickie.

The minutes of the two previous meetings were read and approved.

The first paper of the evening was read by Mr. W. J. Cuthbertson, in which he suggested a "Solution of Metropolitan Transit," by the provision of central structures for the street car and vehicle traffic, and subways for all utilitarian conduits. The suggestion was illustrated by sketches showing the ideas involved in this method of proposed municipal improvement.

A discussion of this subject took up most of the evening, after which the Secretary read a paper, written by Mr. James C. Bennett, entitled "A Method of Filing Notes, Clippings and Sketches," which was also discussed.

The meeting thereupon adjourned.

Otto von Geldern, *Secretary.*

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The Banquet of the Technical Society of the Pacific Coast, December 16, 1905. — In this event, held at the Merchants Club in San Francisco, sixty members and guests participated. The President

acted as toastmaster, and a most pleasant evening was spent in thus concluding the Autumnal Meeting of the Society.

In the address of the President, Mr Dickie referred to the long struggle of the Society, and its constant desire to accomplish something to benefit the engineer. He related his own experiences in his career on the Pacific coast, from the time of his arrival in San Francisco,referring to his connection with many engineering works of the state.

The members and friends parted at midnight by singing "Auld Lang Syne."

Otto von Geldern, *Secretary.*

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San Francisco, January 5, 1906. — Regular meeting called to order at 8 o'clock p.m. by President Dickie.

The report of the Nominating Committee was read as follows:

January 5, 1906.

To Members of Technical Society,
San Francisco, Cal.

*Gentlemen,* — Your Nominating Committee takes pleasure in presenting the following names for nomination of officers for the coming year:

For President — Mr. George W. Dickie.
For Vice-President — Mr. Franklin Riffle.
For Secretary — Mr. Otto von Geldern.
For Treasurer — Mr. E. T. Schild.
For Directors — Mr. Carl Uhlig, Mr. Hermann Barth, Mr. Marsden Manson, Mr. H. D. Connick, Prof. Herman Kower.

Respectfully submitted,

S. G. Hindes,
W. J. Cuthbertson,
Edw. F. Haas,
S. C. Irving,
Adolf Lietz,
*Nominating Committee.*

Upon motion the report was ordered received, the committee discharged, and the Secretary instructed to prepare and circulate ballots to be opened on the evening of the annual meeting, January 19, 1906.

The chair appointed as tellers for the ballot Messrs. W. J. Cuthbertson and Harry Larkin.

A note was read from Mr. M. H. Strouse, assistant to the secretary of the Pacific Northwest Society of Engineers, stating that three of the papers read at the Engineering Congress held at Portland in 1905 had been recovered, viz.: "Problems that Confront Engineering and Kindred Industries on the Pacific Coast," by George W. Dickie; "Subterranean Water Supply," by John Richards; and the "Principles Governing the Valuation for Rate Fixing Purposes of Water Works under Private Ownership," by Arthur L. Adams. The expense incurred amounted to twenty dollars, and the Society is asked to contribute a part of this amount in order to reimburse the Pacific Northwest Society for its outlay to recover what is considered the property of the Technical Society.

The Secretary was instructed to communicate with the Pacific Northwest Society and ascertain the pro rata of the Technical Society in the expenditure connected with the recovery of these papers, and that this amount be thereupon drawn on the Treasurer and sent to the secretary with the expressed appreciation of the Technical Society.

Meeting thereupon adjourned.

OTTO VON GELDERN, *Secretary.*

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ANNUAL MEETING, SAN FRANCISCO, JANUARY 19, 1906. — The meeting was called to order at 8.30 P.M. by the President. The ballots for the annual election of officers were opened by the tellers and the following result of the balloting was announced:

For President — George W. Dickie, 55.
For Vice-President — Franklin Riffle, 55.
For Secretary — Otto von Geldern, 54.
For Treasurer — E. T. Schild, 55.
For Directors — Hermann Barth, 55; H. D. Connick, 54; Hermann Kower, 55; Marsden Manson, 54; Carl Uhlig, 55.

These officers were thereupon declared duly elected to serve the Society for the year 1906. The annual reports of the Secretary and Treasurer were read, which were ordered approved and spread in full upon the minutes. The meeting thereupon adjourned.

E. T. SCHILD, *Acting Secretary.*
(In the absence of Otto von Geldern, *Secretary.*)

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ANNUAL REPORT OF THE SECRETARY FOR THE YEAR 1905.

I have the honor to submit to the Society, through its Board of Directors, the following report, containing also that of the Treasurer, showing the condition of the Society on January 19, 1906, the date of the regular annual meeting.

The present total membership is 166, as follows:

| | |
|---|---|
| Honorary member | 1 |
| Life members | 3 |
| Members | 144 |
| Associates | 18 |
| Total | 166 |

Of these the following classification may be made:

| | |
|---|---|
| Resident members | 100 |
| Non-resident members | 48 |
| Resident associates | 17 |
| Non-resident associates | 1 |
| Total | 166 |

Geographically distributed, there are in

| | |
|---|---|
| San Francisco and vicinity | 115 |
| Northern California | 22 |
| Southern California | 5 |

| | |
|---|---|
| Arizona | 1 |
| Colorado | 1 |
| District of Columbia | 2 |
| Hawaii | 3 |
| Kansas | 1 |
| Massachusetts | 1 |
| Nevada | 2 |
| New York | 2 |
| Oregon | 4 |
| Washington | 1 |
| Wyoming | 2 |

FOREIGN.

| | |
|---|---|
| British Columbia | 1 |
| Central America | 1 |
| South Africa | 2 |
| Total | 166 |

Professionally divided there are,

| | |
|---|---|
| Architects | 11 |
| Builders | 7 |
| Chemists | 2 |
| Civil engineers | 77 |
| Draftsmen | 2 |
| Electrical engineers | 5 |
| Instrument makers | 2 |
| Manufacturers | 4 |
| Mechanical engineers | 29 |
| Merchants | 2 |
| Military engineers | 2 |
| Mining engineers | 10 |
| Naval architect | 1 |
| University professors | 5 |
| Surveyors | 7 |
| Total | 166 |

ADMISSIONS IN 1905.

*By Election.*

| | |
|---|---|
| Members | 7 |
| Associate | 1 |

*As Sojourner.*

| | |
|---|---|
| Member | 1 |
| Total | 9 |

Membership of the Society at the end of the year 1904:

| | |
|---|---|
| Members and associates | 173 |
| Admissions in 1905 | 9 |
| Total on membership list during the past year | 182 |

LOSS DURING THE YEAR.

| | |
|---|---|
| By death | 2 |
| By resignation | 9 |
| By suspension | 3 |
| Cessation of membership | 2 |
| Total | 16 |

| | |
|---|---|
| Carried on the membership list during the past year, 1905 | 182 |
| Loss in 1905 | 16 |
| Present membership | 166 |
| Membership at beginning of year | 173 |
| Loss during the year 1905 | 7 |

DEATHS DURING THE YEAR.

1. Burr Bassell, member, died at Los Angeles, Cal., February 25, 1905.

2. Col. George H. Wallis died at San Francisco, March 19, 1905.

During the year the Society added to its membership the following:

BY ELECTION.

*Members.*

Arthur L. Adams, civil engineer, San Francisco, Cal.
Charles E. Beugler, civil engineer, Oakland, Cal.
Russell Chase, civil engineer, Portland, Ore.
S. C. Freeland, civil engineer, Portland, Ore.
Julius M. Howells, civil engineer, San Francisco, Cal.
Willis Polk, architect, San Francisco, Cal.
Clarence R. Weymouth, mechanical engineer, San Francisco, Cal.

*Associate Member.*

William H. Alderson, civil engineer, San Francisco, Cal.

BY ADMISSION AS SOJOURNING MEMBER.

Capt. W. W. Harts, Corps of Engineers, United States Army.
Total, 9.

RESIGNATIONS DURING THE YEAR 1905.

*Members.*

L. J. LeConte, civil engineer, Oakland, Cal.
H. D. Gates, civil engineer, San Francisco, Cal.
Major C. E. Gillette, corps of engineers, United States Army.
R. S. Moore, mechanical engineer, San Francisco, Cal.
James M. Owen, draftsman, San Francisco, Cal.
William C. Pidge, surveyor, San Francisco, Cal.
G. W. Wepfer, mining engineer, non-resident.
J. H. G. Wolf, civil engineer, California.

*Associate Member.*

George Stone, cement manufacturer, San Francisco, Cal.

Total, 9.

SUSPENSIONS DURING THE YEAR 1905.

S. Giletti, concrete builder, New York.

George W. Nicholls, electrical engineer, non-resident.

E. F. Rossow, draftsman, Mare Island.

Mr. John Richards, past president, was made an honorary member during the year, for his eminent services rendered the Society in the past, and as a token of appreciation for them on the part of the members of the Technical Society.

Two meetings were held during the year for the purpose of reading and discussing papers on technical subjects:

THE SPRING MEETING,

in Portland, Ore., during the Lewis and Clark Exposition, on June 29 and 30, and July 1, 2 and 3, in conjunction with other organizations which participated in holding an Engineering Congress:

Pacific Northwest Society of Engineers, Technical Society of the Pacific Coast, Pacific Coast Electrical Transmission Association, Officers of the Corps of Engineers, United States Army; Engineers of the United States Reclamation Service, Montana Society of Engineers, Washington State Chapter of American Institute of Electrical Engineers.

The following papers were submitted for reading and discussion by members of the Technical Society during this joint congress:

1. "Pacific Coast Industrial Engineering Problems," by George W. Dickie.

2. "The Principles Governing the Valuation of Water Works under Private Ownership," by Arthur L. Adams.

3. "Subterranean Water as Found in the Valleys of California," by John Richards.

4. "Timber Tests — Methods and Results," by Loren E. Hunt.

5. "Reinforced Concrete Construction," by L. A. Hicks.

6. "Control of Hydraulic Mining Débris in California Rivers by the Federal Government," by Capt. W. W. Harts, Corps of Engineers, United States Army.

7. "The United States Reclamation Service," by D. C. Henny, consulting engineer.

THE AUTUMNAL MEETING

was held in San Francisco, December 14, 15 and 16, where the following papers were read and discussed:

1. "Annual Address," by the President, George W. Dickie.

2. "Description of the Polytechnic High School of Los Angeles," by Edward T. Hewitt.

3. "Property in Invention," by Frank P. Medina.

4. "A Suggested Solution of Metropolitan Transit," by W. J. Cuthbertson.

5. "A Method of Filing Notes, Clippings and Sketches," by James C. Bennett.

TREASURER'S REPORT FOR THE YEAR 1905.

| | | |
|---|---|---|
| Cash in bank January 7, 1905 | $474.52 | |
| Cash on hand January 7, 1905 | 44.80 | |
| | | $519.32 |
| Received during the year to January 6, 1906 | | 1 086.40 |
| | | $1 605.72 |
| Expended during the year to January 6, 1906 | | $1 115.21 |
| Cash in bank January 6, 1906 | $481.51 | |
| Cash on hand January 6, 1906 | 9.00 | 490.51 |
| | | $1 605.72 |

The receipts are as follows:

| | | |
|---|---|---|
| Cash in bank January 7, 1905 | $474.52 | |
| Cash on hand January 7, 1905 | 44.80 | |
| | | $519.32 |
| Dues collected | | 878.00 |
| Eight admission fees | | 40.00 |
| Dues, account of Mechanics Institute | | 10.50 |
| Cash for reprints | | 29.20 |
| Sundries, diplomas, etc | | 11.70 |
| Banquet tickets | | 117.00 |
| | | $1 605.72 |

The expenditures are as follows:

| | | | |
|---|---|---|---|
| Sundry expenses, stamps, envelopes, mailing, etc. | | $113.20 | |
| Printing, stenographing, typewriting, etc | | 148.00 | |
| Salary of secretary | | 180.00 | |
| Collecting | | 67.74 | |
| Four assessments, Fred. Brooks, secretary | | 411.57 | |
| Dues, Mechanics Institute | | 20.50 | |
| Reprints, Fred. Brooks, secretary | | 27.70 | |
| Books and subscriptions | | 4.00 | |
| Banquet | $127.50 | | |
| Steward at banquet | 10.00 | | |
| Services at fall meeting | 5.00 | 142.50 | |
| | | | $1 115.21 |
| Cash in bank January 6, 1906 | | $481.51 | |
| Cash on hand January 6, 1906 | | 9.00 | 490.51 |
| | | | $1 605.72 |

## Engineers' Society of Western New York.

ANNUAL MEETING, BUFFALO, N. Y., DECEMBER 5, 1905. — The meeting was held in the rooms of the Society in Ellicott Square at 4 P.M., and in the evening at the Hotel Touraine.

There were present Messrs. Alverson, Babcock, Bassett, Brackenridge, Eighmy, Fairchild, Fell, Haven, Kielland, Knapp, Norton, Ricker and Throop.

The minutes of the last meeting were read and approved.

Messrs. Bassett and Kielland were appointed tellers to count the ballots for officers for the ensuing year.

President Norton announced the following-named persons as having been duly elected:

President — Louis H. Knapp.
Vice-President — Soren M. Kielland.
Director — Frank N. Speyer.
Secretary — Thomas J. Rogers.
Treasurer — Dennison Fairchild.
Librarian — William A. Haven.

The Treasurer presented the following report for the year ending December 5, 1905:

DECEMBER 5, 1905.

TO THE PRESIDENT AND MEMBERS OF THE ENGINEERS' SOCIETY OF WESTERN NEW YORK:

*Gentlemen,* — Herewith I submit for your approval my annual report for the year ending December 12, 1905, as follows:

RECEIPTS.

| | | |
|---|---|---|
| Balance in treasury, December 1, 1904 | | $314.23 |
| From Secretary and others | | 505.75 |
| From banks, interest | | 11.59 |
| Total | | $831.57 |

DISBURSEMENTS.

| | | |
|---|---|---|
| Rent, October 1, 1904, to September 1, 1905, 11 mo. | $261.00 | |
| Association Engineering Society, assessments | 115.00 | |
| Postage, printing and stationery | 60.94 | |
| Binding magazines, etc. | 23.25 | |
| Binding board | 1.60 | |
| Maps and postage on same | 4.51 | |
| Subscriptions for magazines, etc. | 20.70 | |
| Typewriting | 9.47 | |
| Advertisements | 24.00 | |
| Funds in Erie County Bank, December 12, 1905 | 295.68 | |
| Funds in Fidelity Bank, December 12, 1905 | 15.42 | |
| Total | | $831.57 |

BALANCE ON HAND.

| | | |
|---|---|---|
| General fund (Fidelity Bank) | $15.42 | |
| Library fund (Erie County Bank) | 33.44 | |
| Permanent fund (Erie County Bank) | 262.24 | |
| Total | | $311.10 |

Very respectfully,

F. N. SPEYER, *Treasurer.*

The following report was received from the Secretary:

BUFFALO, N. Y., December 5, 1905.

ANNUAL REPORT OF THE SECRETARY FOR THE YEAR, DECEMBER 1, 1904, TO DECEMBER 1, 1905.

TO THE PRESIDENT AND MEMBERS OF THE ENGINEERS' SOCIETY OF WESTERN NEW YORK:

*Gentlemen,* — I herewith beg to submit the following annual report for the year ending December 1, 1905:

MEMBERSHIP.

| | |
|---|---|
| Honorary member | 1 |
| Members | 46 |
| Associates | 9 |
| Juniors | – |
| Total | 56 |

During the year the following changes in membership have occurred:

| | |
|---|---|
| Deaths | 2 |
| Resigned | 8 |
| Indefinitely suspended account of arrears of dues | 17 |
| | 27 |

RECEIPTS AND DISBURSEMENTS.

| | |
|---|---|
| Annual dues | $417.50 |
| JOURNAL advertisements | 80.00 |
| Annual banquet "bal" | .75 |
| | $498.25 |
| Deposited with Secretary | $498.25 |

There are in arrears of dues at present, 15 members on the active list, owing . . . . . $177.50

MEETINGS.

The Society held three meetings, with an average attendance of eleven, against seven meetings and an average attendance of nine the previous year.

Six meetings of the Executive Board were held, with an average attendance of five, against twelve meetings with an average attendance of five for the previous year.

At the regular meetings the following subjects were discussed:

January 3, 1905. "What Should be the Policy of the City Toward the Development of Its Outer Harbor?"

February 7, 1905. "The Union Passenger Station."

October 3, 1905. "The Present Condition of the City Water Works.

An amendment to the Constitution, Act VI, was announced as having been carried at the February meeting, and amendments to the By-Laws, Act VI, Sect. 12, and Act V, Sects. 1 and 2, at the January meeting.

Very respectfully,

H. B. ALVERSON, *Secretary.*

The reports of the Treasurer and Secretary were received and ordered printed, and the President was requested to appoint a committee to audit their accounts.

President Norton made a short address on the state of the Society and took occasion to thank the members for their interest in the affairs of the Society. Informal remarks were made by Messrs. Bassett, Brackenridge, Babcock, Kielland and Ricker.

A vote of thanks to the retiring officer was unanimously adopted.

H. B. Alverson, *Secretary.*

# Association of Engineering Societies.

Vol. XXXVI. FEBRUARY, 1906. No. 2.

## PROCEEDINGS.

### Engineers' Club of St. Louis.

St. Louis, January 17, 1906. — The Engineers' Club of St. Louis held its 609th meeting on Wednesday evening, January 17, 1906, at the Club rooms, 3817 Olive Street, President Layman in the chair. Present also, thirty-four members and eight guests.

The minutes of the 608th meeting were read and approved.

In the absence of the Secretary, the President presented a partial report of the 400th meeting of the Executive Committee.

New applications for membership from the following gentlemen were read: Herbert William Wolff, Henry Clay Henley, Grant Beebe, John C. Van Doorn, Walter Lee Flower, Wesley W. Horner.

The applications of the three following gentlemen, which were read at the last meeting, having been referred to the sponsers for further information, were again presented:

Frank W. Combs, Edward G. Cowdery, Samuel Carson McCormack.

The applications of the following gentlemen having been duly approved, were voted upon and the men named elected: W. A. Baehr, J. R. Cullinane, C. W. Koiner, A. S. Partridge, H. F. Rosenow, A. H. Timmerman, G. A. Watkins.

The President presented for action by the Club a recommendation of the Executive Committee that a vest-pocket list of the Club membership be printed, the cost to be borne by a sufficient amount of advertising at twenty dollars per page.

After some discussion it was moved (Van Ornum) and seconded that the matter be referred back to the Executive Committee for further consideration, particularly with regard to the elimination of advertising, and also with regard to the form of the publication.

A substitute motion, duly seconded and accepted by Van Ornum, was made by R. S. Colnon, that the Secretary be authorized to publish a roster of Club membership, without advertising, at a cost not to exceed $250, and in a form to be fixed by the Executive Committee.

The motion was amended to read that the publication be in pamphlet form, of the size of the Journal.

The last amendment was then amended to read that the pamphlet contain, in addition to the membership list, the Constitution and By-

Laws, and such other matter as the Executive Committee may direct. Amendment carried.

Preceding amendment, as amended, carried.

Original motion, as amended, carried.

The President announced that Mr. Swope was unable to accept the appointment to the Membership Committee and that Mr. Wm. H. Bryan had been appointed to fill the vacancy.

The discussion of the evening was then opened by Mr. S. Bent Russell, who read extracts from a paper by Mr. A. J. Himes, entitled, "The Position of the Constructing Engineer and His Duties in Relation to Inspection and the Enforcement of Contracts," and added his views of the subject from the standpoint of the engineer. Mr. R. S. Colnon replied from the standpoint of the contractor.

The discussion was also participated in by Messrs. Robert Moore, Wm. H. Bryan, E. R. Fish, S. B. Russell, R. S. Colnon and Mr. J. N. Ostrom of Pittsburg.

Adjourned.

A. S. Langsdorf, *Secretary pro tem.*

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St. Louis, February 7, 1906. — The 610th meeting of the Engineers' Club of St. Louis was held at the Club rooms, 3817 Olive Street, Wednesday evening, February 7, 1906, President Layman presiding. Forty members and five visitors were present.

The minutes of the 609th meeting were read and approved, and the minutes of the 401st meeting of the Executive Committee were read.

Applications for membership were read from Henry Elliot and Perse Abram Morse.

The following, having been approved by the Executive Committee, were elected members of the Club: Grant Beebe, F. W. Combs, E. G. Cowdery, W. L. Flower, H. C. Henley, W. W. Horner, S. C. McCormack, J. C. Van Doorn, H. W. Wolff.

The President announced the following Entertainment Committee for 1906: H. J. Pfeifer (chairman), A. S. Langsdorf, J. V. Hanna, W. H. Baehr, W. H. Henby.

The report of the Executive Committee, relating to the appointment of a committee to furnish information to the Club regarding the investigations which are being made by the United States Geological Survey Testing Plant located in St. Louis, was presented to the Club. After remarks by Messrs. Flad, Bryan and Holman, Mr. Flad moved that such a committee be appointed. The motion was carried.

The President named the following men to serve on the committee: Edward Flad (chairman), M. L. Holman, Robert Moore, W. H. Bryan.

An invitation was read from the Academy of Science, inviting the Engineers' Club to be represented at the dinner commemorative of the fiftieth anniversary of the foundation of the academy. The Secretary was instructed to ascertain more definitely regarding the nature of representation desired by the Academy of Science.

The report of the examiner appointed to audit the Treasurer's accounts for 1905 was read to the Club. The report showed the Club to be in excellent financial condition and the Secretary's and Treasurer's records correct.

Mr. Robert Moore moved that the Library Fund be made $250 for the year 1906, the total ($250) to include the amount at present in the Library Fund.

The paper of the evening, upon "Railroad Construction in the Southwest; or, Meeting with Extremes," by Mr. H. Rowher, was fully illustrated by lantern slides. The paper would have provoked considerable discussion, but owing to the lateness of the hour, the discussion was postponed until the following meeting.

Adjourned.

R. H. FERNALD, *Secretary.*

## Civil Engineers' Club of Cleveland.

RESOLUTIONS on the death of Mr. William Chisholm (adopted January 9, 1906):

*Whereas*, It has pleased the Divine Power, whose ways are beyond mortal ken and before whose chastening dispensation we humbly bow, to remove from this life our esteemed associate, William Chisholm; therefore, be it

*Resolved*, That in the death of William Chisholm the Civil Engineers' Club of Cleveland loses a faithful member, an earnest supporter, an encouraging influence and a gracious personality.

*Resolved*, That we, the members of the organization, mourn the loss of one whose fellowship was uplifting, whose friendship was unwavering, whose gentle and unobtrusive nature endeared him to all who knew him, and whose vacant chair in our broken circle will long be a tender reminder of the bereavement we sustain through the loss of his counsel and his companionship. And be it further

*Resolved*, That these resolutions, suitably engrossed, be sent to the family of our late associate, and that they be furnished to the local newspapers for publication.

(Signed) JASON A. BIDWELL,
GUSTAVUS A. HYDE,
C. R. HINCHMAN,
*Committee.*

REGULAR MEETING, FEBRUARY 13, 1906, at the Club rooms, called to order by the President at 8.15 P.M. Present, fifty members and twelve visitors, the latter including Messrs. Lehman and Schmitt, architects for the new Court House, and Mr. John Eisenman, who were especially invited to be present at this meeting.

Minutes of preceding meeting read and approved.

Applications from the following for active membership, approved by the Executive Board, were read: Charles John Conlin, George Ellis Daniels, M.E., Philip A. Geier, John Christian Ulmer, Clarence H. Judson (transfer from Toledo Club) and John Christian Streng (transfer from Detroit Society).

The following amendment to the Constitution was reported from the Executive Board with the unanimous approval of the Board, and was referred to letter ballot at the next regular meeting of the Club: Article II, Section 6, to read as follows: "Honorary members shall be gentlemen of acknowledged preëminence in engineering, architecture or applied science. They shall be subject to neither fees nor assessments. The number of honorary members shall be limited to *ten*." The word "ten," at the end of the section is substituted for "six" in the original.

Mr. Hanlon, chairman of the Grade Crossing Committee, submitted the appended majority report from his committee, signed by himself and Mr. Cox, together with a minority report, also appended, signed by Mr. Hoffman, the third member of the committee.

After an extended discussion, taken part in by Colonel Kingman and Messrs. Hanlon, Hoffman, Tinker and Lane, a motion by Mr. Hoffman was carried to accept the majority report and refer back to the committee the question of minimum clearance considered desirable, for further investigation and report at the next regular meeting.

The Nominating Committee submitted the following list of nominations for officers for the ensuing year: For President, Dr. Dayton C. Miller; Vice-President, Charles H. Wright; Secretary, Joseph C. Beardsley; Treasurer, Walter M. Allen; Librarian, Harry S. Nelson; First Director, Robert O. Rote; Second Director, Henry M. Lane; and Director to fill out the unexpired term of Mr. Wright, Henry M. Lucas.

(Signed) CHARLES S. HOWE, *Chairman.*

The list was referred to letter ballot at the annual meeting, without discussion.

Mr. Hoffman presented for endorsement by the Club, H. B. No. 122, Mr. Lersch, now pending in the General Assembly, "to investigate the construction, the methods of operation and the efficiency of all water purification works and sewage purification works in use by cities, villages and public institutions in the state of Ohio," and providing an appropriation of $7 500 per annum therefor, for two years. The Secretary reported that the Committee on Water Pollution had examined the proposed bill and approved its provisions. On motion of Mr. Lane, seconded by Colonel Kingman, the Secretary was instructed to communicate with the legislative delegation from this county, urging the adoption by the Assembly, of the proposed legislation.

Gen. J. A. Smith then presented the paper of the evening, a discussion of "Some Phases of Foundations for Buildings in Cleveland."

Following the reading of the paper, at the suggestion of Mr. Boalt, Messrs. Lehman and Schmitt, architects for the new Court House, were invited to take part in the discussion. Mr. Lehman responded by presenting an exhaustive paper on the subject of the Court House foundation which appears in the discussion of General Smith's paper.

Mr. Hanlon then moved to adjourn for two weeks and to continue the discussion at the special meeting to be held at that time. Carried.

Lunch was served after adjournment.

JOE C. BEARDSLEY, *Secretary.*

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CLEVELAND, OHIO, January 22, 1906.

TO THE PRESIDENT AND MEMBERS OF THE CLEVELAND ENGINEERS' CLUB, CITY:

*Gentlemen*, — Your committee, appointed to consider the clearance height of the overhead bridge on Detroit Street, where the same crosses the N. Y. C. & St. L. R.R., reports as follows:

The plans of the structure and the work as far as it has been completed have been examined, and it was found that the height of 16 ft. 3 in. was established by mutual consent of both parties, the City and the

Railway Company, under Section 333717 D. of Ohio Laws, passed May 2, 1902, which provides that a municipality may compel the separation of grades, where the plans and specifications are reasonable and practicable, and that this height of 16 ft. 3 in. is in the minimum.

The new street grade of 4 per cent. on East approach and 0.6 per cent. on West approach has been established with a minimum damage to abutting property. In order to establish this grade, it was necessary to lower the railway tracks about four feet, which change is possible without causing an unsightly dig in the grade line.

To have made further depression of the tracks would have required several expensive changes of sewers, water and gas mains.

To have raised the structure to a clearance of 21 ft. above the tracks, as now depressed, would add approximately $40 000 to the property damages.

It is to be regretted that a legal height of less than 21 ft. is permissible over any main line of railway track, as such can only be a source of great danger to the employees, who have no recourse to damages.

*Therefore*, this committee would recommend that legislation be enacted that will raise the minimum to as near 21 ft. as possible.

(Signed) W. B. HANLON.
J. D. COX.

CLEVELAND, OHIO, February 1, 1906.

MR. W. B. HANLON,
303 Electric Building, City:

*Dear Sir*, — I return herewith report of committee appointed by the Civil Engineers' Club of Cleveland, to investigate the clearance of the Detroit Street Bridge over the tracks of the N. Y. C. & St. L. R. R.

While I am heartily in accord with the spirit of the report, I must take exception to the recommendation, that the legislature be petitioned to change the act that now makes 16 ft. 3 in. the minimum clearance, where municipalities are seeking to abolish grade crossings. To go to even a large expense in order to obtain 21 ft. clearance in order to protect lives of train men is certainly justifiable, but there often arise cases, and here in Cleveland they have arisen, where the insisting upon obtaining 21 ft. clearance would probably prevent the abolition of the grade crossings. I believe a clearance of less than 21 ft. is decidedly better than the continuance of a grade crossing.

The changing of the present act which permits a less clearance than 21 ft. under certain conditions would, therefore, seem unwise, and I think we can rest assured that the railway companies will always insist on the maximum clearance, as not only are the lives of their employees in danger but also the freight-carrying capacity would be curtailed by too small a clearance.

Yours truly,

(Signed) ROBERT H. HOFFMAN.

## Engineers' Club of Minneapolis.

Annual Meeting, January 22, 1906. — The 185th meeting was called to order after the annual dinner, participated in by about 40 members at the Dayton Tea Rooms, by President Burch, who, after some brief remarks on the good attendance and thanking those present from the sister club in St. Paul, introduced Captain Powell, engineer in charge of the lock and dam work in the river (midway district). He spoke briefly of the progress of his work; of its "locking the two cities together," and pictured a handsome club building to occupy well-kept grounds in the midway district, and to be occupied by the amalgamated clubs of both cities.

O. Claussen, of St. Paul, expressed the hope that the cordial relations that had always existed between the clubs would continue; his club was always glad to coöperate in advancing any and all good works, public or private.

Professor Hoag followed in a few brief remarks, after which Mr. White, city engineer of Superior, gave a short talk on the experience he was having with their sewer system, and some of their engineer problems. The other speakers were: Mr. Annan, of St. Paul; C. A. P. Turner, Prof. J. M. Tate, Minneapolis; and Mr. Winslow, St. Paul. ' The regular business meeting followed. President's, Secretary's, Treasurer's and Librarian's annual reports were read and placed on file. The election of officers was by ballot and resulted as follows:

President — James B. Gilman.

Vice-President — W. E. Stoopes.

Secretary — O. P. Bailey.

Treasurer — H. A. Rogers.

Librarian — W. W. Redfield.

Representative to the Association of Engineering Societies — E. P. Burch.

Committees appointed were:

Finance Committee — J. M. Tate, C. L. Pillsbury.

Program and Entertainment Committee — H. B. Avery, C. A. P. Turner, Walter S. Pardee.

Auditor — W. W. Redfield.

## Montana Society of Engineers.

Lewistown, Mont., January 13, 1906. — The nineteenth annual meeting of the Montana Society of Engineers was held in Odd Fellows' Hall, at 10 a.m., President E. W. King presiding. The Secretary being absent, Robt. A. McArthur was appointed Secretary *pro tem*. The following members were present: Messrs. Goodale, Carroll, Dunshee, Vail, Christian, Bowman, Craven, Moulthrop, Winchell, Barker, McArthur, Strasburger, McLeod, Burns, Whitten, Klepinger, Draper, King, Thorpe, Kinney, Borgnis and McClean.

The minutes of the December meeting were read and approved. The applications of the following persons for membership were read: Otto F. Wasmandorff, Henry M. Rae, John McGee, Frank F. Goss, Lyman O. Wilson, A. M. Plumb and R. K. Neill. On motion these applications were approved and the Secretary instructed to issue the necessary ballots, to be canvassed at the next meeting of the Society. The Secretary presented the ballots for membership and Tellers Carroll and Goodale reported H. I. Shaw, J. D. Pope and Geo. Miltenberger duly elected. Ballots for the officers of the Society for 1906 were presented and Messrs. Barker and Vail were appointed tellers. The canvass resulted as follows:

President — Bertram H. Dunshee, of Butte.

First Vice-President — Edward C. Kinney, of Bozeman.

Second Vice-President — Archer E. Wheeler, of Great Falls.

Secretary and Librarian — Clinton H. Moore, of Butte.

Treasurer and Member of the Board of Managers of the Association of Engineering Societies — Sam'l Barker, Jr., of Butte.

Trustee — Geo. W. Wilson, of Butte.

President King retired from the chair and President Dunshee was duly installed as President of the Society for the ensuing year. The reports of the Secretary and Treasurer were read and referred to the proper committee.

The Committee on Mining Laws reported progress. A general discussion on the advisability of this Society withdrawing from the Association of Engineering Societies ensued, and on motion the Secretary was instructed to solicit the written opinion of each member of the Society as to whether or not we shall continue the Journal of the Engineering Association. Here adjournment until 2 p.m. took place.

The meeting was called to order by President Dunshee. The first order of business was the annual address of E. W. King, the retiring President. Following the address was the thesis on "Steam Turbines," by Prof. C. H. Bowman of the School of Mines, at Butte. This paper was discussed at length and much information gained therefrom. Mr. Edward C. Kinney read a paper on a Kansas power plant, constructed by him some years ago. Prof. Geo. W. Craven of the School of Mines gave an excellent written account of the Madison River power plant. The Secretary read several letters of regret from members of the Society expressive of the writer's non-ability to be present. Messrs. Thorpe, Plumb, Goss and Wasmandorff gave short talks on these subjects: Hydraulic Rams, Ore Roasting, Havre Water Works, Water Power Plant at Lewistown. The Secretary was instructed to extend the thanks of the Society to all parties who had contributed to the success of the annual meeting. A banquet in the evening was mentioned and the meeting then adjourned.

Robt. A. McArthur, *Secretary pro tem.*

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Butte, Mont., February 10, 1906. — The regular meeting of the Society for the current month was held at the usual hour in the Society room, No. 225 North Main Street, with President B. H. Dunshee presiding.

On the arrival of a quorum, the following proceedings were had: The minutes of the January meeting were read and approved. The application of Adam Thomas Shurick for membership was read and, after approval, the Secretary was instructed to prepare the necessary ballot, to be canvassed at the next meeting. The ballots of the candidates whose applications were presented at the last meeting were counted and the following persons decided unanimously elected members of the Society: Messrs. Rae, Wasmansdorff, Goss, Plumb, Wilson, Neill and McGee. The Committees on Mining Laws and Library Furniture reported slow progress. The President's annual address and the other papers read at the last annual meeting were ordered sent to the JOURNAL publishers as soon as the Secretary could procure the copies. On motion, all members in arrears for dues for three years were suspended and the information furnished them that reinstatement follows the payment of said dues without further action of the Society. On motion, the following resolution was adopted and the Secretary instructed to send a copy to each member of Montana's congressional delegation.

"*Be it resolved:* The Montana Society of Engineers, believing the Mondell Bill, H. R. 7006, now awaiting congressional action, would, if it should become a law, be of very great benefit to our state educational institutions, would respectfully solicit your favorable consideration and vote in favor of said bill."

The meeting then adjourned.

CLINTON H. MOORE, *Secretary.*

# Association of Engineering Societies.

Vol. XXXVI. | MARCH, 1906. | No. 3.

## PROCEEDINGS.

### Engineers' Club of St. Louis.

St. Louis, February 21, 1906. — The 611th meeting of the Engineers' Club of St. Louis was held at the Club rooms, 3817 Olive Street, Wednesday evening, February 21, 1906.

President Layman presided. There were present about forty-five members and sixty-five guests (total 110). The meeting was an open one and the number of ladies present was extremely gratifying.

A vote of thanks was extended to Colonel Ockerson for donating to the library a number of documents pertaining to the Tenth International Congress of Navigation, held in Milan in September, 1905.

The Club voted to have the President of the Club, Mr. Layman, represent the Club at the dinner of the St. Louis Academy of Science in commemoration of its fiftieth anniversary. In case of the absence of the President it was understood that the Vice-President should serve.

Mr. Henry Elliot and Mr. P. A. Morse were elected members of the Club.

Owing to the fact that so many guests were present to hear Colonel Ockerson's talk on " Some Objects of Interest in Europe," the other business matters of the Club were postponed until the next meeting.

After a very delightful illustrated talk by Colonel Ockerson the members and guests adjourned to the reception rooms of the Club where refreshments were served.

R. H. Fernald, *Secretary.*

St. Louis, March 7, 1906. — The 612th meeting of the Engineers' Club of St. Louis was held at the Club rooms, 3817 Olive Street, Wednesday evening, March 7, 1906, Vice-President Fish presiding in the absence of the President. There were present forty-eight members and six visitors.

The minutes of the 611th meeting were read and approved and the minutes of the 402d and 403d meetings of the Executive Committee were read.

An application for membership was presented from George Percy Cole.

A report was presented by the Committee on Extension of Membership involving several changes in the Constitution and By-Laws. The report recommended the classification of members as active, associate and junior. The report also suggested a reclassification of the present membership after the adoption of the amendments suggested. It was moved by Mr. Rohwer that a copy of this report be furnished each member of the Club and that action be deferred until the next meeting. Motion carried.

Owing to the lateness of the hour on the evening of February 7 it was impossible to discuss the paper presented by Mr. Rohwer at that time. The meeting of February 21 was of such a character that this discussion was postponed until the present meeting. The subject of the paper was "Railroad Construction in the Southwest; or, Meeting with Extremes." The discussion was participated in by Messrs. Robert Moore, Russell, Flad, Van Ornum, Fish, Greensfelder and Rohwer.

The Secretary called attention to the various positions mentioned in the recent circular relating to the Bureau of Information.

The paper of the evening, entitled "Railway Accidents; Their Cause and Cure," was presented by Mr. C. A. Moreno. The paper treated especially of accidents to trains, involving casualties to passengers, which consist chiefly of two classes: namely, collisions and derailments. The writer showed that while the former class is decreasing, the latter has increased to an alarming degree, due almost wholly to defective roadway in its relations to modern equipment and speed of trains. The remedy proposed is governmental supervision of railway construction, which the writer holds is of greater importance than municipal supervision of building construction and which would result in an approximately perfect roadway and the consequent reduction of derailment accidents to a minimum. The interesting discussion was participated in by Messrs. Hanna, Robert Moore, Flad, Russell, Rohwer, Helm, Ockerson, Greensfelder, Adrean and Moreno.

Adjourned.

R. H. Fernald, *Secretary.*

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St. Louis, March 21, 1906. — The 613th meeting of the Engineers' Club of St. Louis was held at the Club rooms, 3817 Olive Street, Wednesday evening, March 21, 1906. President Layman presided. Thirty-eight members and seven visitors were present.

The minutes of the 612th meeting were read and approved. The minutes of the 405th meeting of the Executive Committee were read.

The application of Mr. John Hunter for membership in the Club was read and referred to the Executive Committee.

Mr. George Percy Cole was elected to membership.

The report of the Committee on the Extension of Membership, copies of which had been mailed to each member of the Club, was taken up for action. In order to bring the matter before the meeting the Secretary moved that the report be adopted. Seconded by Mr. Flad. Upon the suggestion of the President, the Secretary changed his motion to cover Section I only, which reads: "The membership of the Club shall be divided into the following classes: Active Members, Honorary Members, Associate Members and Juniors."

After a warm discussion, participated in by about fifteen members, Mr. Wheeler moved to amend the above motion so that Section 1 shall read, "The membership of the Club shall be divided into the following classes: Members, Honorary Members and Juniors." Seconded by Mr. E. C. Parker. The amendment was lost by a vote of twenty-five to two.

After further discussion the motion to adopt Section 1 as read was lost by a vote of nineteen to sixteen.

Mr. H. H. Humphrey then moved that the whole matter be referred back to the committee for revision in the light of the discussion of the evening and that the committee be instructed to report at the next meeting. This motion was amended by Mr. Richard McCulloch so that the committee should be increased to five by the addition of two members who are at present opposed to the report of the committee as it stands.

It was moved by Mr. Wall that the whole proposition be laid on the table. Seconded by Professor Van Ornum. This motion was lost by a vote of twenty to eleven.

Mr. Ockerson moved, as an amendment to Mr. Humphrey's motion, that the report be accepted and filed. This amendment was lost by a vote of eighteen to eight.

Mr. Flad then offered as an amendment that the committee be increased to seven instead of five as suggested by Mr. McCulloch's amendment. This amendment was lost by a vote of sixteen to eight.

Mr. Humphrey's motion with Mr. McCulloch's amendment was next voted upon. The motion was lost by a vote of eighteen to seventeen.

It was then moved by Mr. Flad that further discussion of the entire matter be deferred until the next meeting. This motion was carried unanimously.

Owing to the lateness of the hour it was necessary to postpone the paper of the evening on "Mechanical Draft," by Prof. J. H. Kinealy.

The Secretary announced that Prof. H. B. Shaw, of the University of Missouri, would present a paper on "The Electric Drive," at the next meeting of the Club, to be held April 4, and requested Professor Kinealy to present his paper at the meeting of the Club to be held April 18.

The President of the Club, Mr. Layman, presented a written report as delegate to the fiftieth anniversary celebration of the Academy of Science of St. Louis, held Saturday evening, March 10, at the Mercantile Club. He also transferred to the Club a bronze souvenir medal commemorating this semi-centennial. The following resolutions were adopted by the Club:

*Whereas*, The Academy of Science of St. Louis marks with the year 1906 the attainment of the fiftieth year of successful and unbroken existence as an organization devoted to the advancement of science: and,

*Whereas*, By virtue of many interests in common and a long period of intimate relationship, the Engineers' Club entertains a peculiarly cordial attitude toward that organization:

*Therefore, be it resolved*, That the Engineers' Club of St. Louis extends greetings to the Academy of Science of St. Louis on the attainment of its fiftieth anniversary; that we felicitate it upon its magnificent record of valuable contributions to scientific literature; and that we extend to it as an organization our friendly cooperation and our best wishes for its continued prosperity. May it retain a high standard of excellence in the field of scientific investigation, and by its further good works continue to justify the noble objects and ambitions of its founders.

*Further, be it resolved*, That the Secretary of this Association communicate these resolutions in writing to the president of the Academy of Science.

Adjourned.

R. H. Fernald, *Secretary.*

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April 4, 1906. — The 614th meeting of the Engineers' Club of St. Louis was held at the Club rooms, 3817 Olive Street, Wednesday evening, April 4, 1906, President Layman presiding. Sixty-seven members and fifteen guests were present.

The minutes of the 613th meeting were read and approved.

The order of business was changed and the paper on " The Electric Drive," by Prof. H. B. Shaw was presented before the regular business of the evening.

The paper was of general interest, and prompted discussion from Messrs. Humphrey, McCulloch, Meston, Borden, Bryan, Langsdorf, Russell and Layman.

After the discussion of the paper the supplementary report of the Committee on Extension of Membership was presented.

In the absence of the chairman, Mr. Zeller, the secretary of the committee, Mr. Bryan, explained the details of the report and pointed out the points of difference between the supplementary and original reports.

Mr. Flad moved that the report of the committee be accepted and the thanks of the Club be extended to the committee for the excellent work it has done. The motion was carried.

Mr. Brenneke moved the adoption of the report in its entirety and also moved that the amendments to the Constitution be sent out to letter ballots. Seconded by many.

After some discussion Mr. Hanna moved as an amendment that each clause be considered separately. This amendment was accepted by Mr. Brenneke. Amendment adopted.

Section 1 of the Constitution aroused considerable discussion, but was finally adopted as read, by a vote of 61 to 3.

Section 2 of the Constitution adopted as read.

Section 3 of the Constitution adopted as read.

Section 4 of the Constitution adopted as read.

Section 5 of the Constitution adopted as read.

Section 6 of the Constitution adopted as read.

It was moved by Mr. Flad that the amendments to the Constitution be adopted as a whole and be sent out for letter ballot. Motion carried.

Adjourned.

R. H. Fernald, *Secretary.*

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## Civil Engineers' Club of Cleveland.

Semi-Monthly Meeting, February 27, 1906, called to order in the rooms of the Club by the President. Present, fifty members and visitors.

The discussion of General Smith's paper was continued, the President giving a brief outline of the original paper. Mr. B. F. Morse submitted a written contribution to the discussion, which was read by the Secretary.

Messrs. Hoffman, Lehman, Green, Lane, Schowalter and others then took part in the verbal discussion that followed. On motion of Mr. Osborn, a vote of thanks was tendered the non-members who had taken part in the discussion.

Mr. W. J. Carter gave a brief account of the various routes that have been mentioned for the proposed high-level bridge to connect the east and west sides, with his reasons for advocating the location of the bridge on the Franklin-Superior St. route. Discussion was taken part in by Messrs. Ritchie, Morse, Palmer, Lane and others. On motion of Mr. Palmer, the following committee was appointed to investigate the proposed routes and report to the Club the one that, in their opinion, will best meet the necessities of the city: Gen. J. A. Smith, N. P. Rice, F. C. Osborn, Jas. Ritchie and F. F. Prentiss.

Adjourned.

Joe. C. Beardsley, *Secretary.*

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Annual Meeting, March 13, 1906, at Chamber of Commerce Club.

The meeting was called to order by the President about 8.30 p.m., after dinner, which was served at 7 p.m. Present, eighty-three members and six visitors. Minutes of regular and semi-monthly meetings in February were read and approved.

The following applications for active membership, approved by the Executive Board, were read: Will K. Monroe, B.S.; Robert Stevens Parsons, C.E.; and William von Wolffradt.

The tellers, Messrs. Howe and Nelson, reported the election of the following officers for the ensuing year:

For President — Dr. Dayton C. Miller.

For Vice-President — Charles H. Wright.

For Secretary — Joseph C. Beardsley.

For Treasurer — Walter M. Allen.

For Librarian — Harry S. Nelson.

For Directors (term expires 1908) — Robert O. Rote, Henry M. Lane.

For Director (term expires 1907) — Henry M. Lucas.

The tellers, Messrs. Rote and Nelles, reported the adoption of the proposed amendment to Article II, Section 6, of the Constitution, as follows:

At the regular meeting of the Executive Board, February 6, 1906, the following amendment was unanimously approved and it was read and referred to letter ballot at the regular meeting of the Club, February 13, 1906: Art. II, Sect. 6, last line, substitute the word "ten" for "six," the section reading as amended:

"Section 6. *Honorary.* — Honorary Members shall be gentlemen of acknowledged preëminence in engineering, architecture or applied science. They shall be subject to neither fees nor assessments. The number of Honorary Members shall be limited to ten."

The tellers, Messrs. Evans and Estep, reported the election to active membership of the following: Charles John Conlin, George Ellis Daniels, Philip A. Geier, Clarence H. Judson, John Christian Streng, John Christian Ulmer.

Printed copies of the financial reports of the Secretary and Treasurer were submitted and the former read the following report as to membership:

MEMBERSHIP SUMMARY.

| | Hon. | Retired. | Active. | Asso. | Corresp. | Total. |
|---|---|---|---|---|---|---|
| Membership, March 1, 1905.. | 6 | 6 | 176 | 14 | 26 | 228 |
| Elected.......... | | | 43 | 4 | 1 | 48 |
| Transferred: | | | | | | |
| (other societies) | | | 2 | | | 2 |
| (other classes).. | | 3 | | | 6 | 9 |
| Total gain....... | | 3 | 45 | 4 | 7 | 59 |
| Died............ | | | 2 | | | 2 |
| Resigned........ | | | 3 | 1 | 2 | 6 |
| Canceled......... | | | 1 | 1 | | 2 |
| Transferred: | | | | | | |
| (other classes).. | | | 9 | | | 9 |
| Dropped......... | | | 3 | | | 3 |
| Total loss........ | | | 18 | 2 | 2 | 22 |
| Membership: March 1, 1906.. | 6 | 9 | 203 | 16 | 31 | 265 |

Mr. H. M. Lane, chairman, Program Committee, submitted the report of his committee for the year, hereto appended.

Mr. C. H. Wright, senior representative of the Club on the House Committee, gave an interesting summary of the work of that body and outlined work that he thought should be taken up for the coming year. He particularly emphasized the necessity of solving the Club rooms problem satisfactorily before our present lease expires (April, 1907) and the desirability of maintaining an adequate reference library. His ideas were embodied in the following resolutions which were unanimously adopted:

*Resolved*, first, That it is the sense of this meeting that the Club should take active steps to see if quarters, suitable and satisfactory to the majority of the members, cannot be obtained at a lower rental than we are now paying; and, at the same time, the question should be considered as to whether or not it is possible to take some action which will result in the Club eventually owning its own Club house.

Second, That some plan should be devised and carried out systematically, year by year, which will result in our securing and maintaining an up-to-date reference library.

Third, That it is the sense of this meeting that this Club might be a much more important factor in the community than it is at present, if each member would feel that he has a personal responsibility in carrying on the work for which the Club was formed.

The following members gave short talks on the recent progress in their several fields of activity: Mr. James Ritchie, civil engineering; Mr. Charles W. Hopkinson, architecture; Prof. C. H. Benjamin, mechanical engineering; Mr. Robert Hoffman, municipal engineering.

Gen. William Sooy Smith, an honored guest of the Club on this occasion, then gave an interesting and forceful talk on the career of engineering with especial reference to the education and duties of engineers.

The address of the President, which concluded the exercises of the evening, gave a humorous and interesting account of his experiences while on a South American trip early in the past year.

Adjourned.

JOE. C. BEARDSLEY, *Secretary.*

## Financial Reports of Secretary and Treasurer for Year Ending February 28, 1906.

### Secretary's Report.

PERMANENT FUND.

| | | | |
|---|---|---|---|
| Balance, March 1, 1905 | | $1 288.69 | |
| Fees | $225.00 | | |
| Interest | 56.06 | 281.06 | |
| Taxes | | | $11.27 |
| Balance, February 28, 1906 | | | 1 558.48 |
| Total | | $1 569.75 | $1 569.75 |

GENERAL FUND.

| | | | |
|---|---|---|---|
| Balance, March 1, 1905 | | $23.09 | |
| Dues, Active | $1 867 50 | | |
| ,, Associate | 112.00 | | |
| ,, Corresponding | 135.00 | | |
| ,, Delinquent ($95.00, 45.00, 25.00) | 165.00 | | |
| ,, 1906 | 20.00 | 2 299.50 | |
| Advertising | | 86.00 | $10.35 |
| Books and periodicals | | | 39.45 |
| Commissions | | | 11.90 |
| Entertainment | | 70.75 | 487.09 |
| Certificates | | | 9.40 |
| Incidentals | | | 14.10 |
| Journal | | 9.55 | 449.38 |
| New quarters, subscription | | 2.00 | 2.00 |
| Reporting | | | 19.60 |
| Printing | | | 172.28 |
| Postage | | | 101.45 |
| Stationery | | | 33.87 |
| Associated Tech. Clubs | | | 972.00 |
| Secretary | | | 150.00 |
| Telephone (extra name) | | | 6.34 |
| Balance | | | 11.68 |
| | | $2 490.89 | $2 490.89 |

SUMMARY.

| | | |
|---|---|---|
| March 1, 1905, balance Permanent Fund | $1 288.69 | |
| March 1, 1905, balance General Fund | 23.09 | |
| Receipts, Permanent Fund | 281.06 | |
| Receipts, General Fund | 2 467.80 | |
| Disbursements, Permanent Fund | | $11.27 |
| Disbursements, General Fund | | 2 479.21 |
| February 28, 1906, balance Permanent Fund | | 1 558.48 |
| February 28, 1906, balance General Fund | | 11.68 |
| | $4 060.64 | $4 060.64 |

BILLS RECEIVABLE.

| | |
|---|---|
| From members (dues) | $137.00 |
| From members (note) | 53.00 |
| | $190.00 |

BILLS PAYABLE.

| | |
|---|---|
| Printing | $19.90 |
| Secretary | 50.00 |
| Association Engineering Societies | 172.90 |
| | $242.80 |

JOE. C. BEARDSLEY, *Secretary.*

TREASURER'S REPORT.

| | | |
|---|---|---|
| Received from former Treasurer, February 28, 1905: | | |
| Permanent Fund | $1 288.69 | |
| General Fund | 23.09 | |
| | | $1 311.78 |
| Received from Secretary up to February 28, 1906: | | |
| On account Permanent Fund | | 225.00 |
| On account General Fund | | 2 463.50 |
| On account Interest Permanent Fund | | 56.06 |
| Total | | $4 056.34 |
| Disbursed General Fund | $2 474.91 | |
| Disbursed Permanent Fund — Taxes | 11.27 | |
| | | 2 486.18 |
| Balance | | $1 570.16 |
| Balance on hand, February 28, 1906: | | |
| Permanent Fund | | $1 558.48 |
| General Fund | | 11.68 |
| Total | | $1 570.16 |

Respectfully submitted,

ARTHUR G. MCKEE, *Treasurer.*

ANNUAL REPORT OF THE CHAIRMAN OF THE PROGRAM COMMITTEE OF THE CLEVELAND CIVIL ENGINEERS' CLUB.

During the spring and early fall the Program Committee held several meetings, and the members proposed such a list of good things in the way of program that the chairman has had no difficulty in filling the program for each meeting. We have had eleven meetings or gatherings of the Club during the past year, for nine of which the Program Committee furnished programs or has assisted in providing entertainment.

On May 5 Dr. Richard Moldenke, secretary of the American Foundrymen's Association and chairman of one of the committees of the Society for Testing Materials, described the work of the Society for Testing Materials to the engineers, and pointed out the necessity for such work. The society presented the Club with some of the past transactions, and the Club later voted to become a member of the society and subscribe for the transactions regularly.

On May 23 J. S. Lane, of Akron, Ohio, gave an illustrated lecture entitled, "The Gold and Diamond Fields of South Africa." The meeting was well attended and the members seemed to enjoy the program.

On June 13 Mr. Robert Hoffman and Mr. Walter P. Rice presented the subject of the "Intercepting Sewer System for Cleveland."

The Program Committee had nothing to do with the summer outing, and hence can claim none of the honor for that successful trip.

On September 30 the engineers were the guests of the Conneaut Dock Company. By the courtesy of Mr. A. W. Johnston, general manager of the Nickel Plate, we were tendered the use of a private car to take the members to and from Conneaut. The trip occupied the entire day, and we believe that all who went felt amply repaid.

On October 10 Mr. F. C. Osborn read a paper on "Engineering Ethics and Fees," which provoked considerable discussion.

The meeting of November 14 was arranged for by other officers of the Club, but the Program Committee was very glad indeed to have Mr. Gustavus A. Hyde tell us of his fifty years' experience with the weather, and we were also pleased to have with us Mr. James Kencaley, local observer for the United States Weather Station, Ensign W. L. Varnum of the United States Hydrographic Office and Rev. F. L. Odenbach of St. Ignatius College.

Such meetings as this, at which we can pay our tribute to men who have given a life study to some phase of engineering or other subject of importance in which we are all interested, should certainly be encouraged in the future.

On December 12 Gen. Jared A. Smith was to give a talk on the "Dynamics of Sunlight," but at the last moment had to give it up on account of illness, and hence there was an impromptu discussion on the subject of "Concrete."

On January 9 Mr. N. H. Harrington, of Lansing, Mich., gave a very interesting talk on the "Use of the Suction Gas Producer for Power Purposes," bringing out many points of interest in the use of this style of apparatus, by which far greater efficiency is obtainable than by the ordinary steam boiler and steam engine.

On February 13 Gen. J. A. Smith read an exceedingly interesting paper entitled, "Some Phases of Foundations for Buildings in Cleveland, with Special Reference to the Court House Foundation." As this paper provoked considerable discussion, a special meeting was held on February 27, at which the discussion was continued, and at which Mr. Carter, city engineer, also presented an interesting paper on the High Level Bridge between the business center of Cleveland and the west side.

In conclusion, I wish to thank the members of the Program Committee for their readiness to serve and for the prompt way in which they attended committee meetings when they were called, and also wish to express my gratitude to the members of the Club for the hearty way in which one and all have aided in the work, when they were called upon for suggestions or services. The year's work has certainly been a pleasure, and I can only hope that the next chairman will find as much hearty support.

The object which the Program Committee has attempted to carry out during the previous year has been to bring before the members of the Club subjects of local or special engineering interest and, at the same

time, to intersperse these with a sufficient number of evenings devoted to topics of general interest.

If the chairman of the outgoing committee may make a suggestion for the future guidance of any member who may succeed him, it will be that an attempt be made to divide the subjects discussed as evenly among the different classes of engineers interested, and thus achieve the same ends that would be secured if he had sections devoted to different branches of engineering.

If this broader program is carried out, it will probably be found necessary to hold special meetings almost every month during the fall, winter and spring.

H. M. Lane, *Chairman, Program Committee.*

## Boston Society of Civil Engineers.

Boston, February 21, 1906. — A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.45 o'clock p.m., President John W. Ellis in the chair; 230 members and visitors present.

The record of the last meeting was read and approved.

Messrs. Henry B. Drowne and Winslow H. Herschel were elected members of the Society.

On motion of the Chairman of the Committee on Excursions, the thanks of the Society were voted to Benj. W. Wells, Fire Commissioner of Boston, and Mr. B. F. Flanders, Superintendent of the Fire Alarm, and his assistants, for courtesies shown members of the Society on the occasion of the visit to the Boston Fire Alarm Station this afternoon.

The literary exercises consisted of a very interesting account by Mr. Frederic P. Stearns of the reports of the Board of Consulting Engineers for the Panama Canal and the general conditions relating to the design and construction of the canal.

The talk was illustrated by numerous lantern slides and a large number of plans and diagrams.

Adjourned. S. E. Tinkham, *Secretary.*

### Twenty-fourth Annual Dinner.

The twenty-fourth annual dinner of the Boston Society of Civil Engineers was held at the Hotel Vendome, Boston, Tuesday evening, March 13, 1906, and was attended by 134 members and guests. The usual informal reception was held at six o'clock and the dinner was served at seven o'clock.

The President of the Society, Mr. John W. Ellis, presided and acted as toastmaster. The following members and guests responded with brief speeches: Mr. Frederic P. Stearns, president of the American Society of Civil Engineers; the Hon. George H. Utter, governor of Rhode Island; Mr. Charles F. Prichard, president of the American Gas Light Association; Mr. M. N. Baker, editor of *Engineering News*; Dr. Frederick W. Hamilton, president of Tufts College; Mr. Harrison P. Eddy, chairman of the Sanitary Section of the Society; Prof. George F. Swain, of the Massachusetts Institute of Technology; and Mr. Henry Manley, past president of the Society. Music was furnished by the Albion Quartet.

SANITARY SECTION.

BOSTON, MASS., MARCH 7, 1906. — The annual meeting of the Sanitary Section of the Boston Society of Civil Engineers was held Wednesday evening, March 7, 1906, at 7.30 P.M., at the Society rooms, Tremont Temple, Boston, Chairman H. P. Eddy in the chair; 70 members and visitors present.

The report of the Executive Committee was read by the clerk, and on motion of L. M. Hastings was accepted and placed on file.

The report of the Committee on Uniform Sewerage Statistics was read, and on motion of C. W. Sherman it was voted that the report be printed and distributed among the members and that the matter be brought up for discussion at an early meeting of the Section.

The following officers were elected for the ensuing year:

Chairman — Freeman C. Coffin.

Vice-Chairman — Robert S. Weston.

Clerk — William S. Johnson.

Executive Committee — Harrison P. Eddy, Arthur T. Safford, Arthur D. Marble.

The literary exercises of the evening consisted of papers as follows:

"An Account of Several of the Small Sewage Disposal Systems which have been Constructed to Protect the Purity of the Metropolitan Water Supply," by William W. Locke.

"The Sewage Disposal Plant at Vassar College," by Ellen H. Richards.

"The Sewage Disposal Plant at the State Colony for Insane at Gardner," by J. J. Van Valkenburgh.

"The Sewage Disposal Plant at the State Normal School at Hyannis," by George H. Wetherbee, Jr.

All of the papers were illustrated with lantern slides.

WILLIAM S. JOHNSON, *Clerk.*

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ANNUAL REPORT OF THE EXECUTIVE COMMITTEE OF THE SANITARY SECTION.

During the year ending March 7, 1906, the Section has enrolled 20 members, 13 of whom were members of the main society. It has lost by death during the same period one member, making the total membership at the present time 167.

During the year six meetings have been held; there has been one excursion and the Section has furnished two papers for one of the regular meetings of the main society.

The attendance at the meetings and the papers presented have been as follows:

March 1, 1905, attendance 38. "Timber Tunneling in Quicksand," by R. K. Porter.

April 5, 1905, attendance 49. "A Winter Visit to Some Sewage Plants in Ohio, Wisconsin and Illinois," by C.-E. A. Winslow.

June 24, 1905, attendance 58. "Excursion to the Sewer Outlets at Deer Island, Nut Island and Moon Island in Boston Harbor.

October 4, 1905, attendance 44. "Breakage in Sewer Conduits; Its Cause, Effect and Prevention," by Alexander Potter.

December 6, 1905, attendance 67. "Sewage Purification at Columbus, Ohio: A Description of the Testing Station, a Synopsis of the

Results Accomplished there and an Outline of the Design of the Proposed Works," by George W. Fuller.

January 24, 1906, attendance 96. A regular meeting of the main society, at which the following papers were furnished by the Section: "An Informal Talk about a Visit, in 1905, to the Percolating Sewage Filters at Birmingham and the Contact Beds at Manchester, England," by L. P. Kinnicutt; "Observations of a Sanitarian in Sicily and Other Parts of Southern Europe," by W. T. Sedgwick.

February 7, 1906, attendance 48. "The Pollution of New York Harbor," by George A. Soper.

The average attendance at the meetings of the Section has been 51. The greatest attendance at any meeting was 67, and the smallest, 38.

All of the papers presented have been, or are to be, printed in the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES. The JOURNAL during 1905 contained 32 papers, of which 12 were furnished by the Boston Society, and of the 12 furnished by the Boston Society, 5 were presented before the Sanitary Section.

The custom of having a dinner in connection with the meetings has been continued with success, the average attendance at the dinners having been 39.

For the Committee,

WILLIAM S. JOHNSON, *Clerk*.

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BOSTON, MARCH 21, 1906. — The annual meeting of the Boston Society of Civil Engineers was held in Chipman Hall, Tremont Temple, at 7.55 o'clock P. M., President John W. Ellis in the chair. Fifty-nine members present. The record of the last meeting was read and approved.

The Secretary read the annual report of the Board of Government, and, on motion, it was accepted and placed on file.

The Treasurer read his annual report, and, on motion, it was accepted and placed on file.

Mr. E. W. Howe, the retiring Treasurer, spoke substantially as follows: "In surrendering the office of treasurer it is due to the Society that I should express my appreciation of the honor conferred upon me, and the confidence shown in continuing me in the office for the past fourteen years. I assure the members that I feel that a great honor has been conferred upon me, an honor which I have done little to merit. I shall always look back upon my fourteen years' connection with the Board of Government with great satisfaction on account of the very pleasant relations with its members.

"In that time there have been on the Board forty-one different members of the Society, and all are members to-day except two, who have passed away; these latter are Mr. Frank L. Fales, a former librarian, who has recently died, and our beloved past president, Albert F. Noyes, who died in 1896.

"The Society has prospered and grown in every way since 1892. At that time the membership was 290; 39 of these have died and 197 are still members, which number is considerably less than one third of our total membership.

"The annual receipts of the current fund for the year preceding my entrance into office were $1 608.68, as against $5 270.77 for the year

just closing. The expenses in 1891–92 were $1 420.68, while for the last year they were $5 706.90, more than four times those of the earlier year.

"The permanent fund transferred to my care by my predecessor amounted to $3 928.78. This has increased to $18 813.33, there having been no loss on any of our investments.

"In 1892 the Society had no rooms, its meetings being held in one of the larger rooms at the American House. The library was stored in a small room at the hotel and was inaccessible to the members except at great inconvenience.

"Congratulating the Society upon its growth and success, which I trust will continue in even greater measure than in the past, and bespeaking for my successor the same kindness and consideration which has been awarded me, I retire to the ranks, thanking all with whom I have been associated for their uniform courtesy and the whole Society for the great honor of its continued choice of me as the custodian of its funds."

On motion of Mr. FitzGerald, the following resolution was unanimously adopted:

*Whereas*, The Boston Society of Civil Engineers for fourteen years has had the benefit of the patient and able management of the funds of the Society by its Treasurer, Mr. Edward W. Howe, who now feels called upon to resign the office which he has so long and so acceptably filled, be it

*Resolved*, That we, members of the above Society, desire to place on record our appreciation of the devoted services which Mr. Howe has rendered the Society, and our sincere regret that he is unable longer to fill the office of Treasurer.

The Secretary read his annual report, which was also accepted and placed on file.

Mr. Adams, for the Committee on Excursions, read the report of that committee, which was accepted and placed on file.

Mr. Ferguson read the report of the Committee on the Library, which was accepted and placed on file.

Mr. FitzGerald read the report of the Committee on Quarters, which was accepted and ordered to be printed.

Mr. Howe made a verbal report for the Committee on Advertisements.

On motion of Mr. Adams, the sum of fifty dollars was appropriated for the purchase of standard engineering books.

On motion of Mr. FitzGerald, it was voted to refer to the Board of Government, with full powers, the appointment of the several special committees of the Society.

The Secretary read a memoir of Dean C. Warren, which had been prepared by J. Albert Holmes and DeWitt C. Webb, a committee of the Society.

The President announced the death of William T. Pierce, a member of the Society, which occurred February 26, 1906, and on motion, it was voted that a committee be appointed to prepare a memoir. The President has appointed as that committee Messrs. E. W. Bowditch and D. W. Pratt.

President Ellis then delivered the following address:

"At this time the work for the year, both yours and mine, is at an end, and I wish again to assure you of my appreciation of being permitted to serve you as your President.

"I should be unjust to my own feelings if I did not first express my sense of gratitude and obligation to our Secretary for his courtesy and

diligence in his service to me; and to the other officers of the Society I am also indebted for their respect and hearty coöperation.

"It is *always* easy to accept an office; it is not so easy to fulfill the duties incumbent upon the office; and one of the most difficult tasks is to make an address at the close of one's service. The question is what to talk about and what to say. The statistics of the financial standing of the Society have been presented fully by the Treasurer. The Board of Government has submitted its annual report, informing you of the membership of the Society, and giving a detailed description of everything that has transpired for the past year. The Library and the Excursion committees and the Sanitary Section have reported in full, so that nothing, in repetition or explanation, is either necessary or entertaining. I wish, however, to emphasize the recommendation of the Board of Government to have it more definitely understood that our regular meetings are open to the many students of our varous schools of technology and colleges with technical departments, without the accompanying attendance of a member of the Society. We are exceedingly fortunate in having so many students within the radius of, say, two miles from our headquarters; and in extending this invitation we are aiding the schools and advancing the interests of the students as well as making our Society popular with them; really a mutual aid to us all.

"It would not seem possible that there is now as much engineering work going on in the vicinity of Boston as formerly; but, although the East Boston Tunnel is finished, we have the Washington Street Subway, Charles River Dam in Boston proper, and throughout the state of Massachusetts various grade-crossing schemes in process of construction or contemplated, as those at Haverhill, Attleboro, Lynn and the railroad tunnel in Providence. The Wachusett Dam and its aqueducts are about completed in this state, and there is naturally a gradual migration of engineers to the additional water supply of New York. There surely is sufficient work at the present time to encourage the young engineer; and the vastness and requirements of the new projects keep the consulting engineer thinking and pondering both day and night.

"I have thought it best not to talk very much of the past, trespassing upon your patience with statistics; nor to endeavor to foretell the future, as I might be tempted to prophesy so much that verification would be impossible hereafter. Nothing, then, is left but the present; and although it apparently seems to be a vacant theme, I will endeavor to speak of our profession as it exists to-day, not only in name, but in actual live practice. It is not what has been done, or is to be done, but what we are doing now.

"The means and manner of commissions arriving at the value of water rights and water-works plants, based upon the evidence of expert testimony, which is usually so comprehensive of itself, the two sides varying radically, would be a welcome and instructive topic; but, personally, I should feel that I was doing an injustice to my associates to divulge or to publish the arguments and deductions of a commission of which I have been a member, especially when the statement would be from a minority, without the full consent of the majority. I can say, however, that with all the evidence submitted in a careful and elaborate manner, based partly on experience and practical knowledge and partly on assumption of cost of production less depreciation, with consideration

of present earning capacity, good-will, future value, purity and source of supply if water is for domestic use, regularity and adequacy of supply if for power purposes, etc., the commissioner or referee is obliged to apply his own knowledge with considerable tact and judgment and make many subdivisions of the evidence in order to make an intelligent report. The evidence, however, must be the foundation upon which the report is made, or it will fail to receive the support of the counsel and the desired confirmation by the court. All valuations obtained through a commission are expensive both in money value and time, and whenever possible settlement should be made without resorting to legal adjudication.

"In actual practice the engineer is called upon, not only to design a plan of his own and to have responsible charge of carrying the plan into execution, but also to examine and pass judgment upon the plans and methods of construction of his associates. There is also involved with such examination an opinion of the value of the work or plant for the ultimate purpose of determining either the fair amount of actual payment for the transfer of ownership or the estimated cost of the work. This is the duty of the expert, and all his statements and conclusions, or technically, his opinion, are to be made under oath. The real meaning of what constitutes an expert has been so mixed up by the lawyers, who have clouded it by definitions and declarations based upon sentiment and sarcasm that even common sense has been eliminated; and yet the engineer who has become skillful through practice and experience is *the expert* who commands respect from the lawyer and the court with his practical opinion. The application of honesty, coupled with the principle of ordinary justice, must and should be the foundation of an expert's opinion.

"This thinking that either our eyesight is affected or the focus of our eyeglasses is wrong, so that the figure six has become the figure nine when we want to swell the amount, or the reverse when we want to contract the amount, for the purpose of valuation, is supreme only on the direct examination, and is usually worthless for the final consideration or decree of the court or commission. The expert who verifies his opinion by his experience, by citations from actual practice, by directly answering the cunning quizzing of the experienced practitioner (very often mixed with a hypothetical solution sufficient to make complete deception), and by an exhaustive study of the actual condition of facts relative to the existing conditions of the property involved, will find his services valued and respected by both contending parties. The court or commission wants facts, not theoretical exploitations of the truth based upon arithmetical deductions or formulas made some time in the middle ages. In this connection I am reminded of the words of our deceased past president, Mr. James B. Francis, which at the time was a lesson to me of itself. During the trial of a case, after a witness had completed his evidence, which was very entertaining, full of assumptions, well tabulated and volubly described, the regular noon intermission was taken, and Mr. Francis, on being asked his opinion of the evidence of this witness replied in his characteristic way: 'A small amount of truth, spread over a great amount of surface.' The practice of the expert tending to criticise the facts as not being what they should be, or what he would have designed or constructed, is embarrassing and very annoying to the court, as it creates a question of unwarranted admission, and allows an objection

to be made, — a vast amount of oratorical discussion, increasing alike the expense of the trial and the volumes of testimony, — entirely valueless and in the end discreditable to the engineer.

"Though the expert engineer from practice and experience is qualified to state his opinion clearly and as he honestly believes the facts to be, he must realize that the law is the regulator of how far and to what extent he can elaborate; he should never attempt to deliver an essay or dissertation to display his particular ability or knowledge, as he will soon be unintentionally instructing the court, provided the lawyers allow this trespass upon their own rights.

"There is another function, besides that of the expert, for an engineer to fill, both naturally and creditably to himself, namely, that of the business man. The engineer, like other human beings, naturally has a mental equipment, and he is a member of a profession which ranks among the highest in the world; from its earliest existence it has continually progressed so that it embraces all the divisions of engineering and takes in the new with the old, as they continue to master Nature's forces, the most recent being the generation of electricity. The engineer is acknowledged to be competent, by the application of the immutable laws underlying his profession, to design and be responsible for the construction of great works, and in doing so he knows the ultimate results to be obtained in the completion of the works; he is primarily the agent for the proper and judicious expenditure of a vast amount of money, to result in the making of colossal fortunes for others. The engineer is capable of directing expenditures for the completed structure or plant, and will so direct or compel the advancement of the several units at the same time that the culmination of the different parts of the project will be simultaneous, without loss of time or payment of interest money, and thus insure a profit-bearing success. From the inception of a usual business undertaking to the time of beginning operations for testing its earning capacity it is strictly an engineering problem; and afterwards during operation questions arise for changes, which must be decided at once and be executed without affecting the operation or earnings of the business. Surely the engineer, being fully acquainted with the details of construction of the plant, and having the discretion, foresight and ability to decide at once whether the changes can be made, can procure the apparatus and constructive material necessary to push the work to completion without unnecessary delay or cost.

"There is too much apathy or silence on the part of the engineer himself in regard to acquiring, receiving or accepting appointments, even of an honorary nature; for such positions are the mere stepping stones to other positions requiring his professional knowledge; and while in the beginning they are only of honor to himself and the profession generally, without compensation, it is through acquaintances formed in these semi-public associations that not only do his talents and value become known and wanted, but he receives appointments with large responsibilities and corresponding compensation. There seems to be a tendency at the present time (and I have thought more particularly so in this locality) to discredit the engineer's fitness to fill positions requiring business activity, and it is the actual fact that recently some of the most prominent commissions where engineering knowledge and experience are a necessary qualification, have been filled by men of legal acquirements only.

"The industries of the country require their affairs to be managed by men of intelligence and executive ability, and who is better qualified than the designer and constructor to manage and direct, or, in fact, to make a success of his own work? Such a person is the engineer; reinforced by a combination of technical knowledge and scientific training, with administrative foresight and executive ability, having more than the average amount of intelligence and force, he will take charge and be successful as the head and brains of our principal industries.

"While the engineer should be one of the foremost leaders in civilization he should also be identified with the social side of life and make progress in mingling with the public, both commercial and political; in fact, broaden out from the technical to the practical, and then become fitted for contact and exchange of opinions with all grades of humanity.

"In conclusion, as an engineer *is* 'a person of genius or ingenuity,' he should be ingenious enough to have his genius recognized, while maintaining his principles of right and justice, so well defined and practiced in his profession that there is never a need of the reminder to 'stand pat' where his integrity and honesty is in question, as the words 'Not for sale' are indelibly inscribed on the escutcheon of every engineer, whether he is in good standing on the rolls of any engineering society, or is practicing his profession either as an expert, or as a business man."

At the conclusion of the address the tellers of election, Messrs. Nathan S. Brock and Franklin M. Miner, submitted the result of the letter ballot, and in accordance with their report the following officers were declared elected:

President — Frank W. Hodgdon.
Vice-President (for two years) — Leonard Metcalf.
Secretary — S. Everett Tinkham.
Treasurer — William S. Johnson.
Librarian — Frank P. McKibben.
Director (for two years) — Charles T. Main.

Before declaring the meeting adjourned, the President presented the President-elect, Mr. Hodgdon, who thanked the Society for the honor conferred upon him, and promised his best efforts to further the interests of the Society for the coming year.

S. E. Tinkham, *Secretary.*

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## Annual Report of the Board of Government for the Year 1905–1906.

*To the Members of the Boston Society of Civil Engineers:*

In compliance with the requirements of the constitution, the Board of Government submits its report for the year ending March 21, 1906.

At the last annual meeting the total membership of the Society was 592, of whom 563 were members, 2 honorary members, 12 associates and 15 members of Sanitary Section only.

During the year we have lost 12 members; 6 by resignation, 3 by forfeiture for non-payment of dues, and 3 have died.

There have been added to the Society during the year a total of 41 members, of whom 1 is an associate and 7 are members of the Sanitary Section only.

The present membership of the Society consists of 2 honorary mem-

bers, 13 associates and 606 members, of whom 22 are members of the Sanitary Section only; making the total membership 621.

The record of deaths during the year is, Dean C. Warren, died July 6, 1905; Frank L. Fales, died October 5, 1905; and William T. Pierce, died February 26, 1906.

Ten regular and one special meetings of the Society have been held during the year, and the Twenty-fourth Annual Dinner was given at the Hotel Vendome on March 13, 1906. The average attendance at the regular meetings was 87; the largest being 230, and the smallest 29. The attendance at the annual dinner was 134.

At the regular meetings the following papers have been read:

March 15, 1905. — President Frederick Brooks' address upon "Some Changes in Arithmetic to Decimal Reckoning."

April 17, 1905. — Mr. Harold K. Barrows, "Work of the Hydrographic Branch of the United States Geological Survey in New England, and a Discussion of Methods Used for Estimating Stream Flow." (Illustrated.)

May 17, 1905. — Mr. George G. Shedd, "The Garvins Falls Dam and Canal and Hydro-Electric Plant"; Mr. Edward B. Richardson, "The Hydro-Electric Development at Garvins Falls Dam." (Illustrated.)

June 21, 1905. — Prof. Charles M. Spofford, "The Making of Structural Steel"; Prof. John E. Hill, "The Engineering Building at Brown University." (Illustrated.)

September 20, 1905. — Mr. George W. Blodgett, "Recent Developments in the Old Colony Street Railway System." (Illustrated.)

October 18, 1905. — Capt. William H. Jaques, "The Russian-Japanese War of 1904–5; Its Scope and Meaning." (Illustrated.)

November 15, 1905. — Mr. George B. Francis, "Construction of Water Power on the Chattahoochee River at Atlanta, Ga." (Illustrated.)

December 20, 1905. — Mr. George S. Rice, "Construction of the New York Subway." (Illustrated.)

January 24, 1905. — Prof. L. P. Kinnicutt, "An Informal Talk about a Visit in 1905 to the Percolating Sewage Filters at Birmingham and the Contact Beds at Manchester, England" (Illustrated); Prof. William T. Sedgwick, "Observations of a Sanitarian in Sicily and Other Parts of Southern Europe." (Illustrated.)

February 21, 1906. — Mr. Frederic P. Stearns, "Discussion of the Report of the Board of Consulting Engineers for the Panama Canal." (Illustrated.)

Two informal meetings have been held in the Society's library during the year. The subjects discussed at these meetings have been as follows:

December 18, 1905. — Laurence B. Manley, "Relocation of Underground Pipes and Conduits on Account of the Building of the Subway and Tunnels in Boston." (Illustrated.)

February 14, 1906. — Sanford E. Thompson, "Proportioning of Concrete."

From the report of the Executive Committee of the Sanitary Section it appears that six meetings of the Section have been held, with the average attendance of 51. At all of these meetings interesting papers have been presented which have been printed in the Journal. The Society has paid for rent, for the use of the stereopticon and for reporting these meetings, the sum of $183.50.

The report of the Treasurer shows that our income for the year available for current expenses has not equaled our expenditures by $436.13. The present balance on hand in the current funds is only $20.20 against $456.33 a year ago. In explanation of this deficit, it should be stated that there have been some unusual expenditures this year due to the enlargement of our quarters, and for doing a larger amount of binding for the library than in former years. The amount expended for furniture and repairs exceeds that of last year by $237, and the cost of binding has increased over last year by $46.40; this accounts for $283.40 of the total deficit, leaving $152.73 to be accounted for in some other way. This latter sum, however, is substantially the same as the deficit of a year ago. Of the items of expense which have exceeded that of last year, that of rent will remain about the same for some time in the future, while the other items will continue to increase with, and in proportion to, the growth of the Society. It would seem, therefore, that the only practical method of caring for the deficit is either by increasing the income from advertisements in the JOURNAL, or by reducing our current expenses. The net income from advertisements this year has been $104.50 less than last year.

Under authority of a vote of the Society, passed at the meeting held April 12, 1905, there has been executed with the Tremont Temple Baptist Church, a lease for three years from June, 1905, for the enlarged quarters which the Society now occupies. This lease has been made in accordance with the offer of the management of Tremont Temple, which was given in the report of the minority of the Committee on Quarters, submitted last March. For an increased annual rental of $300 the Society has for its own use an additional room adjoining the one which it formerly had, and the long corridor in front of these rooms has been partitioned off and made available for book shelves and reading purposes. A lease has also been made with the New England Water Works Association for three years, and the New England Association of Gas Engineers and the Hersey Manufacturing Company still continue with us as tenants at will. The changes seem to meet the present needs of the Society, and will probably be sufficient for the period covered by the lease.

The Board of Government believes that the practice begun some years ago of buying standard engineering books for the Society has proved beneficial, and would recommend that the sum of fifty dollars be appropriated for the purchase of such books for the coming year.

It has been suggested that if it were more generally known that persons not members of the Society were always welcome at our meetings when papers are read and discussed, it would increase the usefulness of the Society and tend to strengthen its membership. The Board recommends that members extend a cordial invitation to all whom they think may be interested in subjects discussed at the meetings, to be present whenever they find it convenient, and to assure them that they will always be welcome whether the member extending the invitation be in attendance or not. It is particularly desirable that all students engaged in technical studies at our colleges and institutions and young men just beginning work, be urged to attend our meetings.

For the Board of Government,

JOHN W. ELLIS, *President.*

## Abstract of the Treasurer's and the Secretary's Reports for the Year 1905–1906.

### CURRENT FUND.

*Receipts:*

| | | |
|---|---|---|
| Dues for 1904–1905 | $10.00 | |
| Dues for 1905–1906 | 3 918.00 | |
| Dues for 1906–1907 | 57.00 | |
| Sales of Journals | 3.25 | |
| Rent of rooms | 1 000 00 | |
| Advertisements | 282.52 | |
| Balance on hand, March 16, 1905 | 456.33 | |
| | | $5 727.10 |

*Expenditures:*

| | | |
|---|---|---|
| Rent | $1 937.50 | |
| Association of Engineering Societies | 1 517.61 | |
| Printing, postage and stationery | 607.43 | |
| Salaries of Secretary, Librarian and Custodian | 550.00 | |
| Furniture and repairs | 262.00 | |
| Incidentals | 155.65 | |
| Stereopticon | 115.00 | |
| Binding | 104.00 | |
| Reporting meetings | 103.50 | |
| Commission on advertisements | 84.40 | |
| Annual dinner | 69.80 | |
| Periodicals | 51.25 | |
| Lighting | 43.38 | |
| Books | 34.95 | |
| Clerical work for Librarian | 38.88 | |
| Library maintenance | 31.55 | |
| | | $5 706.90 |

| | |
|---|---|
| Balance on hand, March 21, 1906 | $20.20 |
| Amount to credit of Current Fund, March 16, 1905 | $456.33 |
| Excess of expenditures over receipts | $436.13 |

### PERMANENT FUND.

*Receipts:*

| | | |
|---|---|---|
| Thirty-one entrance fees, Society | $310.00 | |
| Seven entrance fees, Sanitary Section | 35.00 | |
| Interest on deposits, savings banks | 260.05 | |
| Interest on bond | 36.00 | |
| Interest, Old Colony Trust Company | 25.40 | |
| Subscription to Building Fund | 100.00 | |
| Balance on hand, March 16, 1905 | 750.01 | |
| | | $1 516.46 |

*Expenditures:*

| | |
|---|---|
| Dues on shares Merchants' Co-operative Bank | $300.00 |
| Dues on shares Volunteer Co-operative Bank | 300.00 |
| Dues on shares Workingmen's Co-operative Bank | 300.00 |

| | | |
|---|---|---|
| Deposited in Provident Institution for Savings | $47.74 | |
| Deposited in Boston Five Cents Savings Bank | 44.52 | |
| Deposited in Eliot Five Cents Savings Bank | 42.72 | |
| Deposited in Warren Institution for Savings | 42.10 | |
| Deposited in Institution for Savings in Roxbury | 41.66 | |
| Deposited in Franklin Savings Bank | 41.25 | |
| | | $1 160.05 |
| Balance on hand, March 21, 1906 | | $356.41 |

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PROPERTY BELONGING TO THE PERMANENT FUND, MARCH 21, 1906.

| | |
|---|---|
| Twenty-five shares Volunteer Co-operative Bank | $4 200.50 |
| Twenty-five shares Workingmen's Co-operative Bank | 3 833.48 |
| Twenty-five shares Merchants' Co-operative Bank | 2 193.83 |
| Deposit in Provident Institution for Savings | 1 400.68 |
| Deposit in Boston Five Cents Savings Bank | 1 306.36 |
| Deposit in Eliot Five Cents Savings Bank | 1 252.89 |
| Deposit in Warren Institution for Savings | 1 236.84 |
| Deposit in Institution for Savings in Roxbury | 1 222.17 |
| Deposit in Franklin Savings Bank | 1 210.17 |
| One Republican Valley R. R. Bond. No 2 (par value) | 600.00 |
| Cash on deposit in Old Colony Trust Company | 356.41 |
| | $18 813.33 |
| Amount of fund as per last annual report | 17 613.75 |
| Increase during the year | $1 199.58 |

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TOTAL PROPERTY OF THE SOCIETY IN THE POSSESSION OF THE TREASURER.

| | |
|---|---|
| Permanent Fund | $18 813.33 |
| Current Fund | 20.20 |
| Total | $18 833.53 |
| Amount as per last annual report | 18 070.08 |
| Increase during the year | $763.45 |

## Report of Committee on Excursions.

Boston, March 21, 1906.

*To the Members of the Boston Society of Civil Engineers:*

The Committee on Excursions submits herewith its annual report.

Eleven excursions have been made during the year, as follows:

April 12, 1905. — Tunnel under Fort Point channel at Dover Street Bridge. Attendance, 13.

May 27, 1905. — Wachusett Dam and Reservoir, Clinton, Mass. Attendance, 76.

June 24, 1905. — Point Shirley and the sewer outlets at Deer Island. Nut Island and Moon Island, under the auspices of the Sanitary Section, Attendance, 58.

July 22, 1905. — Henderson's Point, Portsmouth Navy Yard. Attendance, 220.

August 12, 1905. — Official test of New Dry Dock, Charlestown. Attendance, 15.

September 20, 1905. — Quincy Point Power Station. Attendance, 9.

October 18, 1905. — Motor Mart at Park Square. Attendance, 45.

November 15, 1905. — New Cambridge Bridge and Charles River Dam. Attendance, 50.

January 24, 1906. — Revere Rubber Company. Attendance, 21.

February 21, 1906. — Central Fire Station. Attendance, 14.

March 21, 1906. — Washington Street Tunnel. Attendance, 105.

Total attendance, 626; average attendance, 57.

Twenty-four pages of the *Bulletin of Engineering Work* have been published during the year. The Committee wishes to thank those who have aided in this work.

There is a cash balance of $35.23 in the hands of the Treasurer.

Respectfully submitted,

Edward P. Adams, *Chairman*,
Walter H. Norris, *Sec'y and Treas.*,
Clarence T. Fernald,
Herbert R. Stearns,
L. Lee Street,
*Committee on Excursions.*

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Report of the Committee on the Library.

*To the Members of the Boston Society of Civil Engineers:*

The Committee on the Library begs leave to make the following report for 1905–1906:

During the past year the library has been enlarged and completely rearranged. It now seems that the new quarters are adequate for some time to come.

There have been accessioned since the last annual meeting two hundred and eighty-eight (288) bound volumes, which is approximately fifty per cent. more than was accessioned during the preceding year. Of these new accessions thirteen (13) volumes were purchased by the Society.

The number of books taken from the library during the past year is two hundred and twenty-six (226), an average of nineteen (19) per month. The average taken out per month before the rearrangement of the library was sixteen (16). Since the change the average per month has been twenty-one (21).

The Committee wishes to recommend that the practice of purchasing standard engineering books for the library be continued for the coming year.

Respectfully submitted,

Frank P. McKibben,
F. I. Winslow,
John N. Ferguson,
H. K. Barrows,
*Committee on the Library.*

## Report of the Committee on Quarters.

*To the Members of the Boston Society of Civil Engineers:*

As the Society during the past year has been through an important crisis in connection with its quarters, it seems wise to place on record a brief statement of the movement.

The lease of the present rooms in Tremont Temple expired in June, 1905. These rooms had been the home of the Society for nine years. They consisted of a library, 42 ft. by 17 ft., and an adjoining room, 12½ ft. by 17 ft., this latter leased to a sub-tenant. The meetings of the Society were held in Chipman Hall, seating 350 persons. The New England Water Works Association occupied a portion of the library as a sub-tenant, and for two years the Association of Gas Engineers had also been a sub-tenant.

Owing to a steady growth both in the library and in the membership, the Society, in 1905, was beginning to feel very much cramped for room.

In this dilemma two plans were submitted to the Society by the Committee on Quarters; one contemplated an expansion in its old position by adding more space to the present rooms, and the other involved a radical change to new quarters in a building which the Suffolk Real Estate Trust proposed to erect on Broad Street, between Doane and Central streets. This building was to be named the Engineering Building, and as it was proposed to collect tenants as far as possible who should be engineers or interested in engineering matters, the agents for the proposed building intended to make the offer to the Society an attractive one.

Other schemes were examined by the Committee, who gave much time to the consideration of every matter connected with the whole subject. These two plans, however, were the principal ones before the Society.

Finally, on April 12, 1905, a special meeting of the Society was held to act upon this important question.

At the meeting a majority report, signed by seventeen members and brought before the Society on March 15, was submitted, and also a minority report, signed by two members. The former recommended moving to the new building, and the latter, the enlargement of the old quarters in Tremont Temple.

The Society adopted the minority report, which was strengthened by the fact that many members who had signed the other report abandoned their position at the last moment.

We have now only to consider the plan adopted by the Society, and to describe the way in which it was carried out.

Briefly, the plan involved leasing an additional room adjoining the old rooms, and adding the corridor or hallway in front of the old rooms to the library by building of partitions at the ends of the hall. This work was carried out in June, 1905. The trustees of the building aided the Society in every way in their power, and expended the sum of $350 in adding the corridor to the library, and for this improvement they agreed to ask no additional rent; the only new charge for rent being $300 for the front room. The amount expended by the Society in various ways in connection with the changes in the quarters was $253.70.

The improvements have certainly added very much to the available space for the library and to the comfort of the members, and there seems every prospect that the Society may remain for several years in its present convenient situation. The time will undoubtedly soon arrive when another move will have to be made. For many years the Society has been struggling to secure a position where its growing wants could be met without plunging its treasury into debt. It has pursued a wise policy. It has created a library, enlarged its sphere of influence and accumulated a permanent fund, which is growing steadily. If judiciously managed as in the past, it will not be many years before this fund will have increased to such dimensions that the Society will be justified in securing what may be called, in fact, "Permanent Headquarters."

For the Committee.

Desmond FitzGerald, *Chairman.*

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## Montana Society of Engineers.

Butte, Mont., March 10, 1906. — The regular meeting of the Society for the current month was held in the Society room at the usual hour, President Dunshee presiding. At the opening of the meeting the following members were present: Adami, Bowman, Barker, Dunshee, Goodale, Klepinger, McArthur, Moore, Putnam and Winchell, A. N. The minutes of the February meeting were read and approved. Thomas A. Shurick, of Diamondville, Wyo., by a canvass of a regular ballot, was found to be unanimously elected to membership in the Society. In the matter of the withdrawal of the Society from the Association of Engineering Societies, the Secretary read nineteen letters from members opposing such action, and one in favor of so doing. On motion, made and carried, it is declared the sense of the members present at this meeting that this Society continues its subscription to the Journal and remain in the Association. The Secretary reported that the President's address and the papers read at annual meeting held at Lewistown, Mont., had been sent to the Society Journal for publication. Dr. F. W. Traphagen, of the Colorado School of Mines, for many years connected with Montana's educational institutions, gave an account of an ingenious method for locating the source of some stolen gold bullion by chemical analysis. He also gave an outline of a prospective trip of the senior class of the Colorado School of Mines as follows: The class, consisting of more than thirty members, will leave Golden, Colo., April 29, visit numerous mines and reduction works in Colorado, thence go to Utah for similar investigations. They expect to arrive in Butte May 5, and remain here twelve days, then go to the Black Hills and reach home the day before graduation. They will travel by special car and be accompanied by several professors of the Mining School. In view of their visit here, the Secretary of this Society was instructed to procure a suitable meeting place for the evening sessions of these students. The Society then adjourned.

Clinton H. Moore, *Secretary.*

# Association of Engineering Societies.

Vol. XXXVI. APRIL, 1906. No. 4.

## PROCEEDINGS.

### Engineers' Club of St. Louis.

St. Louis, April 18, 1906. — The 615th meeting of the Engineers' Club of St. Louis was held at the Club rooms, 3817 Olive Street, Wednesday evening, April 18, 1906, Vice-President Fish presiding. Twenty-five members and three guests were present.

The minutes of the previous meeting were read and approved.

The application of Mr. F. R. Mott was presented.

Mr. John Hunter was elected a member of the Club.

The Secretary read letters from Colonel Ockerson and from Governor Francis relating to the conferring of a commemorative diploma upon the Engineers' Club of St. Louis for its active interest and coöperation in the Louisiana Purchase Exposition. The Secretary reported that he had been informed that such a diploma had been prepared for the Club.

The report of the Executive Committee upon the result of the letter for the proposed amendments to the Constitution was as follows:

| | |
|---|---|
| Total vote cast | 141 |
| Required to carry the amendments | 94 |
| Voted in favor of amendments | 130 |
| Voted against amendments | 10 |
| Informal | 1 |
| | 141 |

The proposed amendments to the By-Laws were considered for action as designated in the notices for this meeting, sent out April 10, 1906.

It was moved that the proposed amendments to the By-Laws be taken up by sections. Motion carried.

Professor Van Ornum moved that Section 2 of the By-Laws be adopted as read. Motion carried.

Mr. Fay moved that Section 7 of the By-Laws be adopted as read. Motion carried.

The paper of the evening, by Prof. J. H. Kinealy, upon "Mechanical Draft" was presented. The paper treated of the advantages and disadvantages of mechanical draft systems and discussed the general details of chimney draft, induced draft and forced draft. It further

dealt with the methods of operating power plants under each of the above-named conditions, together with the probable relative cost of maintenance, operating expense, etc. The paper further treated of the utilization of economizers. The discussion was participated in by Messrs. Bryan, Fish, Fernald, Metzger and Kinealy.

Adjourned.

R. H. Fernald, *Secretary.*

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St. Louis, May 2, 1906. — The 616th meeting of the Engineers' Club of St. Louis was held at the Club rooms, 3817 Olive Street, Wednesday evening, May 2, 1906, Vice-President Fish presiding. Thirty members and thirteen guests were present.

The minutes of the 615th meeting were read and approved. The report of the 406th meeting of the Executive Committee was read.

The Secretary read a letter from Mr. H. A. Hunicke, Corresponding Secretary of the Academy of Science of St. Louis, thanking the Club for its resolution of congratulation at the time of the fiftieth anniversary of the founding of the Academy.

The application of Mr. Robert L. Lund for membership was read and referred to the Executive Committee.

At this point Mr. Fish yielded the chair to President Layman, who had in the meantime arrived.

Mr. P. M. Bruner then presented the paper of the evening on "Reinforced Concrete Residences." Mr. Bruner described a residence of this type recently erected by the P. M. Bruner Granitoid Company in St. Louis. Numerous photographs, showing the house in the different stages of construction were exhibited, together with sectional and detail drawings of parts of the structure.

The discussion was participated in by Messrs Van Ornum, Fish, McCulloch, Beebe, Layman, Toensfeldt, Holman, Bary and Lindau, and covered such points as the relative costs of concrete and brick or stone construction, porosity of concrete walls, finished appearance and systems of reinforcement in general.

It was announced that the paper for the next meeting would be on "Recent Developments in Electric Railroading," by A. S. Langsdorf.

Adjourned.

A. S. Langsdorf, *Secretary pro tem.*

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## Civil Engineers' Club of Cleveland.

Regular Meeting, April 10, 1906, at the Club rooms, called to order by the President at 8.15 p.m. Present, thirty-six members and nine visitors.

In the absence of the Secretary, Mr. Lane was elected Acting Secretary.

Minutes of preceding meeting read and approved.

The application of Mr. John Gammell for associate membership was read. The Secretary announced that the President had appointed the following committee to investigate and report upon the subject of new club rooms, the lease on the present quarters and the agreement with the other clubs expiring on April 1, 1907: Cox, Wright, Allen, Neff and

Beardsley; also that the following members had been added to the Water Pollution Committee: Robert Hoffman, George T. Nelles and Charles A. Cadwell. The President announced the Standing Committees for the ensuing year.

The tellers reported the election to active membership of Will K. Monroe, Robert S. Parsons and William von Wolffradt.

The paper of the evening was read by Mr. F. C. Osborn and was an account of his recent trip to South America.

Adjourned.

H. M. Lane, *Acting Secretary.*

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Regular Meeting, May 8, 1906, at the Club rooms, called to order by the Vice-President at 8.15 p.m.; present, forty members and visitors.

Minutes of preceding meeting read and approved.

Applications for active membership of Henry P. Brack, Sidney W. Brainard and Arthur E. Peters, approved by the Executive Board, were read.

The tellers, Messrs. Schowalter and Cadwell, reported the election to associate membership of John Gammell.

A communication from the secretary of the House Committee was read, requesting to know the wishes of the Club relative to continuing the present arrangement as to association of the clubs for club room purposes; as to the retention of the present quarters; and as to the annual outing of the clubs. The appointment of the club's Committee on New Quarters was considered to have answered that part of the communication and on motion of Mr. Lane it was voted to endorse the proposition to have an outing, favorably.

Mr. Hanlon, chairman of the Grade Crossing Committee, read two communications relative to clearance, and on motion of Mr. Evans, they were ordered received and filed.

The following resolution of the Secretary was unanimously adopted:

"Believing that Mr. F. S. Barnum is unusually well qualified by education, experience and high personal character for the position of Superintendent of Construction of the new county buildings, it is hereby

"*Resolved*, That the Civil Engineers' Club of Cleveland unqualifiedly endorse and urge his appointment to that position; and that the Secretary be directed to transmit a copy of this resolution to the County Buildings Commission."

The paper of the evening, "Road Legislation and Construction in Massachusetts," was then read by Mr. Asa Goddard, secretary of the Automobile Club.

Adjourned. Joe. C. Beardsley, *Secretary.*

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## Detroit Engineering Society.

Detroit, April 27, 1906. — At the twelfth annual meeting of the Detroit Engineering Society, held April 27, 1906, in the Employers Association Hall, Stevens Building, the following officers were elected for the ensuing year:

President — Benj. Douglas.

1st Vice-President — W. R. Kales.

2d Vice-President — E. S. Wheeler.

Secretary and Treasurer — Clarence W. Hubbell (reëlected).

The annual meeting was followed by the twelfth annual banquet, at which ninety-eight members were present.

SECRETARY-TREASURER'S REPORT.

MEMBERS.

| | | |
|---|---|---|
| Members, May 5, 1905 | | 156 |
| Added during year | 45 | |
| Resigned during year | 11 | |
| Suspended during year | 2 | |
| Net gain | | 32 |
| Total members, April 27, 1906 | | 188 |

CASH ACCOUNT.

*Receipts.*

| | |
|---|---|
| Cash on hand, May 5, 1906 | $56.91 |
| Dues collected during year | 887.50 |
| From sale of excursion tickets | 120.00 |
| Total received | $1,064.41 |

*Expenditures.*

| | |
|---|---|
| Banquet | $188.55 |
| JOURNAL | 401.25 |
| Excursion | 200.83 |
| Secretary's salary | 100.00 |
| Printing, postage and supplies | 80.28 |
| Cash on hand, April 27, 1906 | 93.50 |
| Total | $1,064.41 |

CLARENCE W. HUBBELL, *Secretary.*

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## Montana Society of Engineers.

BUTTE, MONT., APRIL 14, 1906. — The regular meeting of the Society for April was called to order at the usual hour by President B. H. Dunshee on the arrival of a quorum. The minutes of the last meeting were approved as read. The Committee on Library Shelving reported that the needs of the Society would be met at an early date. The Society read a request from the Engineers' Club of Philadelphia desiring an exchange of library and society room privileges for visiting members of the Engineers' Club to this city. On motion, such an exchange was approved. A letter from President Leonard, of the School of Mines, and Prof. A. N. Winchell, secretary of the National Association of State Mining Schools, having for its object securing speedy action in Congress on the Mondell Bill No. 7006, was read, and the Secretary was instructed to write Speaker Joseph Cannon requesting his good offices in the matter. The Secretary was instructed to invite the senior class of the State School of Mines to attend the next meeting of this Society, also request ex-President King to do likewise. After some discussion, having for its subject, " The Expected Visit of the Senior Class of Colorado School of Mines to this City," the Society adjourned.

CLINTON H. MOORE, *Secretary.*

// ASSOCIATION

OF

ENGINEERING SOCIETIES.

VOL. XXXVI. **MAY, 1906.** No. 5.

# PROCEEDINGS.

## Boston Society of Civil Engineers.

BOSTON, APRIL 18, 1906. — A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 8 o'clock P.M., President Frank W. Hodgdon in the chair; seventy-two members and visitors present.

The record of the last meeting was read and approved.

Messrs. Barzillai A. Rich and John C. Whitney were elected members of the Society.

The Secretary reported for the Board of Government the appointment of the following committees:

Committee on Excursions: L. Lee Street, C. T. Fernald, J. O. De Wolf, E. M. Blake and E. E. Pettee.

Committee on the Library: F. P. McKibben, F. I. Winslow, H. K. Barrows, F. B. Sanborn and H. J. Hughes.

Committee on Quarters: Desmond FitzGerald, E. W. Howe, G. A. Kimball, F. C. Coffin and F. W. Dean.

Members of the Board of Managers, Association of Engineering Societies: S. E. Tinkham, *ex officio*, J. R. Freeman, Henry Manley, Dexter Brackett, Dwight Porter and C. W. Sherman.

Mr. Hiram A. Miller was then introduced and spoke on "The General Features of the Charles River Basin and Dam," and gave a brief review of the construction work to date. The talk was illustrated with lantern slides. In the discussion which followed, Messrs. FitzGerald, Rollins and Miller took part.

Adjourned.

S. E. TINKHAM, *Secretary*.

BOSTON, MAY 16, 1906. — A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.50 o'clock P.M., President F. W. Hodgdon in the chair; ninety-eight members and visitors present.

The record of the last meeting was read and approved.

Messrs. Harold S. Boardman, Horace P. Hamlin and William E. Mott were elected members of the Society.

The Secretary read a communication from the Secretary of the American Water Works Association extending an invitation to the members of this Society to attend the annual convention of the Association to be held in Boston July 10–14, 1906. On motion of Mr. Coffin, it was voted to accept the invitation, and the Secretary was directed to express the appreciation of the Society for the honor conveyed. The Board of Government was authorized to extend to the Water Works Association such courtesies as seemed to it best.

The Secretary reported for the Board of Government that it had appointed the following as the members of the Committee on Advertisements: The Treasurer and the Secretary of the Society and Mr. F. A. Barbour.

Prof. Lewis J. Johnson then gave an informal account of some "Recent Tests of Reinforced Concrete Beams," illustrated by lantern slides. A discussion followed in which Professors Swain and McKibben and Messrs. Wason, Larned, Thompson and others of the Society took part. Mr. H. W. Telford, of the Engineering Department of Harvard University, supplemented Professor Johnson's account of the tests made in the laboratory of the university on concrete beams, and Professor McKibben spoke particularly of tests made at the Massachusetts Institute of Technology on the shearing strength of concrete cylinders.

Adjourned.

S. E. Tinkham, *Secretary.*

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Sanitary Section.

A regular meeting of the Sanitary Section of the Boston Society of Civil Engineers was held at the Point Shirley Club, Winthrop, Mass., Saturday, June 9, 1906.

Horace H. Chase, of Boston, was elected a member of the Section.

The form of Uniform Sewerage Statistics, recommended by a special committee at the March meeting and considered at a special meeting of the Section April 11, 1906, was adopted. It was voted that the printing and distribution of the blank forms be left to the Executive Committee.

Mr. William F. Morse read a paper upon "Modern Methods of Garbage Disposal," which was discussed by the members present.

Previous to the meeting the members visited the plants of the City Refuse Utilization Company on Atlantic Avenue and of the New England Sanitary Product Company on Spectacle Island and enjoyed a sail around the harbor.

Forty-one members and guests attended the meeting and excursion.

W. S. Johnson, *Clerk.*

# Association of Engineering Societies.

Vol. XXXVI. JUNE, 1906. No. 6.

## PROCEEDINGS.

### Boston Society of Civil Engineers.

Boston, Mass., June 20, 1906.— A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 8 o'clock p.m., President Frank W. Hodgdon in the chair; twenty-eight members and visitors present.

The record of the last meeting was read and approved.

Messrs. William T. Blunt, Bertram W. Ransom and John W. Storrs were elected members of the Society.

The Secretary read a memoir of William T. Pierce, a member of the Society, which had been prepared by Ernest W. Bowditch and Daniel W. Pratt, a committee of the Society.

The Secretary announced the death of the following members of the Society: John J. Howard, died May 18, 1906; Isaac K. Harris, died May 21, 1906; and E. Elbert Young, died June 1, 1906. On motion, the President was requested to appoint committees to prepare memoirs of the deceased members.

The President has appointed the following committees: On memoir of John J. Howard, Mr. H. V. Macksey; on memoir of Isaac K. Harris, Mr. Otis F. Clapp and E. F. Dwelley; and on memoir of E. Elbert Young, Mr. H. A. Carson.

Prof. F. B. Sanborn read the paper of the evening, entitled, "Fires and their Prevention in Factories." The paper was fully illustrated by lantern slides.

Mr. S. G. Walker, insurance engineer for Manufacturers' Mutual Fire Insurance Company of Providence, gave a very interesting account of the work of that company.

Adjourned.

S. E. Tinkham, *Secretary.*

# Association of Engineering Societies.

Vol. XXXVII. JULY, 1906. No. 1.

## PROCEEDINGS.

### Montana Society of Engineers.

Butte, Mont., May 12, 1906.—The regular meeting of the Montana Society of Engineers was held at the Society Room, 225 North Main Street, Saturday evening, May 12, 1906, President Dunshee presiding. Quorum present. The minutes of the previous meeting were read and approved.

The Secretary reported the death of Thomas T. Baker, a valued member of the Society, and Messrs. Barker, Hobart and McArthur were appointed a Committee on Resolutions. The Committee on Furniture reported as having completed its labors, and, the result being examined and approved, the committee was discharged.

The Secretary was instructed to have last year's periodicals bound and properly classified in the new bookcases.

Adjourned.

Clinton H. Moore, *Secretary.*

# Association of Engineering Societies.

Vol. XXXVII. SEPTEMBER, 1906. No. 3.

# PROCEEDINGS.

## Engineers' Club of St. Louis.

St. Louis, May 16, 1906.—The 617th meeting of the Engineers' Club of St. Louis was held at the Club Rooms, 3817 Olive Street, Wednesday evening, May 16, 1906, President Layman presiding. Thirty-three members and eleven guests were present.

The minutes of the 616th meeting were read and approved.

Applications for membership in the Club from Fred Blattner Adam and Alfred E. Lindau were presented.

Mr. Robert Loathan Lund and Mr. F. R. Mott were elected to membership in the Club.

Mr. W. H. Bryan, who had recently returned from San Francisco, spoke of the great need of technical books, etc., for the use of the engineers' club of that section. It was moved by Mr. Fish that the sum of $100 be presented to the Technical Club of the Pacific Coast to be used at its discretion; and that a committee of two be appointed to select such duplicate copies of books in the library of the Engineers' Club as may be of use to the engineers of San Francisco and to forward the same to the Technical Club of the Pacific Coast. Seconded by Mr. Moreno. Motion carried. The President appointed Mr. W. H. Bryan and the Secretary as the committee.

The Secretary read a letter from the Board of Water Supply of the city of New York relating to examinations for assistant engineers, topographical draftsmen and rodmen.

The Librarian reported that the books had been entirely rearranged in the Library and explained the present system.

The Secretary reported that the Annual Bulletin was being prepared and would be published as speedily as possible.

The paper of the evening upon "Recent Developments in Electric Railroading," by Prof. A. S. Langsdorf, presented a review of the most important developments in heavy electric railroading in the United States and abroad, with explanations of the types of power, distribution and rolling-stock equipment and their characteristics. The descriptions were illustrated by lantern slides. The discussion was participated in by Messrs. Colby, Beebe, Moreno, Layman, Tropp and McMath.

The Secretary announced that Mr. Bryan had consented to present a paper on the engineering features of the San Francisco earthquake at the next meeting of the Club.

Adjourned.

R. H. FERNALD, *Secretary.*

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ST. LOUIS, JUNE 6, 1906. — The 618th meeting of the Engineers' Club of St. Louis was held at the Club Rooms, 3817 Olive Street, Wednesday evening, June 6, 1906. In the absence of President Layman, Vice-President Fish presided. Thirty-one members and three visitors were present.

The minutes of the 617th meeting were read and approved. The minutes of the 408th meeting of the Executive Committee were read.

Applications for membership from F. B. Adam and A. E. Lindau, as approved by the Executive Committee, were presented for election. These applications were referred back to the Executive Committee with instructions to the committee to designate the class of membership to which each applicant was proposed.

The Committee on Extension of Membership presented a report of progress.

Mr. W. H. Bryan then gave an informal talk on "The Engineering Features of the San Francisco Earthquake." Considerable interest was taken in the discussion, which was participated in by Messrs. Holman, Hanna, Murphy, Fish, Van Ornum, McCulloch, Greensfelder, Henby, Ockerson and Bryan.

Mr. Fish reminded the Entertainment Committee that it was the duty of the committee to arrange for numerous trips during the summer recess.

Adjourned.

R. H. FERNALD, *Secretary.*

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ST. LOUIS, SEPTEMBER 19, 1906. — The 619th meeting of the Engineers' Club of St. Louis was held at the Club Rooms, 3817 Olive Street, Wednesday evening, September 19, 1906. President Layman presided. There were present thirty-nine members and seventeen visitors.

The minutes of the 618th meeting were read and approved. The minutes of the 410th meeting of the Executive Committee were read.

The applications of Alfred E. Lindau for active, and of Fred Blattner Adam for associate membership were voted upon and the applicants declared unanimously elected. The application of John I. Boggs was read and referred to the Executive Committee.

The paper of the evening on the "Reconstruction of the Olive Street Railway Tracks" was presented by Richard McCulloch. A very interesting account was given of the methods pursued in track relaying on the most important thoroughfare of St. Louis, — Olive Street. The paper was illustrated by slides, clearly showing the equipment specially designed for expeditious work in blasting out with dynamite the old cable slot, which lay for years imbedded in solid concrete; and the concrete mixer adapted for effective mixing and discharging of concrete beneath and between the ties, forming a solid roadbed four miles in length. Some important figures in the cost of construction were given, which will form a valuable record for future reference. The discussion was

participated in by Col. John I. Boggs, of Milwaukee; Capt. Robt. McCulloch, Messrs. Moore, Flad, Pfeiffer and Russell. Colonel Boggs compared the advantages of the T-rail, used almost exclusively in Milwaukee for street railway work, with that of the grooved Trilby rail required by St. Louis ordinances. From experience Colonel Boggs stated that the life of the T-rail outlasts that of the Trilby rail more than twice. The T-rail also permitted of rapid-transit conditions in connection with suburban and interurban traffic, which the Trilby rail did not. Mr. Boggs made a strong plea for more intelligent city legislation in this respect.

On motion duly carried the meeting adjourned.

F. E. Bausch, *Secretary pro tem.*

St. Louis, October 3, 1906. — The 620th meeting of the Engineers' Club of St. Louis was held at the Club Rooms, 3817 Olive Street, Wednesday evening, October 3, 1906. President Layman presided. Twenty-four members and nine visitors were present.

The minutes of the 619th meeting were read and approved.

The application of Edwin Dwight Smith was read and referred to the Executive Committee. Mr. John I. Boggs, of Little Rock, Ark., was elected to non-resident membership.

The Secretary read a letter from Colonel Ockerson, stating that he had presented to the Club a copy of "Report of the Board of Consulting Engineers for the Panama Canal," together with maps and diagrams. A vote of thanks was extended to Colonel Ockerson for the donation.

A letter was read from Mr. Otto von Geldern, Secretary of the Technical Society of the Pacific Coast, expressing the appreciation of the Society for the donation of books by the Engineers' Club of St. Louis.

The Secretary read letters calling for men to fill various engineering positions.

The attention of the Club was called to the medal and diploma presented to the Club by the Louisiana Purchase Exposition.

The paper of the evening, entitled, "Present Tendencies of Power Plant Design," was presented by Mr. E. R. Fish. The paper was profusely illustrated by lantern slides and showed the development of steam power plants; electric power with belt transmission; electric power, direct connected; water power; steam turbines; gas producer and gas engine installations, and the transitions from one type of power generation and distribution to another.

After discussion of the paper by Messrs. Lichter, Bryan, Fernald, Layman and Fish, the meeting adjourned.

R. H. Fernald, *Secretary.*

## Civil Engineers' Society of St. Paul.

St. Paul, Minn., October 11, 1906. — A special meeting of the Civil Engineers' Society of St. Paul was held at 2 p.m. Present twelve members, President Claussen in the chair.

The Secretary stated the purpose of the meeting and Mr. Rundlett presented a resolution which was adopted by a rising vote.

*Resolved*, That the Civil Engineers' Society of St. Paul endorse the following memorial:

We meet to-day in special session to honor the memory of Mr. C. A .Winslow, whose sudden death has afflicted this Society with the loss of a faithful officer, has deprived the department in which he has served for the past nineteen years of an efficient and conscientious worker and has bereaved his friends and associates of a man held in affection and the highest esteem.

We extend to his wife and family our sincere sympathy.

On motion of Mr. Starkey, Mr. G. Z. Heuston was unanimously elected as librarian in the place of Mr. Winslow, deceased.

The election of Mr. A. R. Starkey as representative on the Board of Managers of the Association of Engineering Societies in place of Mr. Powell, resigned, was ratified.

The following applicants were elected to membership: Mr. Garrett O. House, Mr. R. A. Tanner, Mr. John S. Potter.

A vote of thanks was accorded Mr. Geo. L. Wilson and the management of the Twin City Rapid Transit Company for courtesies extended to members of the society on September 15.

C. L. Annan, *Secretary.*

## Montana Society of Engineers.

Butte, Mont., October 13, 1906. — The regular meeting of the Montana Society of Engineers was held at the society room, 225 North Main Street, Saturday evening, October 13, 1906, with a good attendance of members and President Dunshee presiding. The minutes of the last meeting were approved as read. Applications for membership from George A. Griggs and Sedman W. Wynne were read, and after approval the Secretary was instructed to circulate the necessary ballots.

The Resolutions Committee on the death of Thomas T. Baker were granted further time to prepare their report. The resignation of John T. Morrow was read and accepted.

The President announced the following Committee on Nomination of Officers for the coming year: Messrs. Charles W. Goodale, Eugene Carroll and George E. Moulthrop.

The Secretary announced the death of Charles W. Leimer, also of George H. Robinson, and the chair named the following committees on resolutions: In case of Mr. Leimer, Messrs. Robert K. Humphrey, Charles W. Goodale and Clinton H. Moore; in case of Mr. Robinson, Frank L. Sizer, William F. Word and Albert S. Hovey.

Adjournment followed.

Clinton H. Moore, *Secretary.*

## Technical Society of the Pacific Coast.

San Francisco, October 5, 1906.— Regular meeting held in the Mechanics' Institute Library hall, and called to order at 8.30 p.m.

A quorum was present.

The Secretary read the following report:

*To the Members of the Society*,— The Secretary took it upon himself to call this, the first regular meeting of the Technical Society, since the catastrophe occurred on April 18, 1906.

The great fire destroyed every possession of the Society, books, records, accounts, copies of the Constitution and all the unbound publications of its transactions, accumulated since 1884. The library had been turned over to the Mechanics' Institute when the Society entered into an arrangement with it to confer upon our members the privileges of the Institute. The Mechanics' Library building, 31 Post Street, was destroyed and all the books with it. The Secretary's office in the Academy of Sciences Building was burned on the morning of the catastrophe, and with this destruction the Technical Society lost all its possessions. The money accounts were in the hands of the Treasurer. These were saved and the cash in bank will be accounted for properly by the Treasurer's report which he will hand you in due time.

Immediately after the fire, the Secretary opened an office in the residence of the Treasurer, Mr. E. T. Schild, 1908 Broadway, San Francisco, who kindly placed at the disposal of the Society his front parlor, where a number of meetings were held in April and in May, and where the business of the Society was transacted for three months. These meetings were attended by technical men irrespective of society affiliation, and their discussions centered upon methods of construction in rehabilitation of buildings.

For the benefit of our refugees, an address book was started, and many engineers registered so that they could be referred to when wanted.

Through the kind offices of several eastern societies and engineers (notably the American Society of Civil Engineers and Mr. John C. Trautwine, Jr., of Philadelphia), stationery, books, drawing instruments and office supplies were sent to the Secretary, an invoice of which is hereunto attached. These were disposed of by him at his temporary office, 1908 Broadway, San Francisco, after the great fire.

A meeting was held by a committee, of which Mr. Edwin Duryea, Jr., was chairman, and which consisted of the following members of the American Society of Civil Engineers and of the Technical Society of the Pacific Coast: Messrs. W. J. Cuthbertson, W. R. Eckart, William Ham Hall, Marsden Manson, R. W. Myers, Franklin Riffle, Luther Wagoner and Otto von Geldern.

Mr. Von Geldern explained in detail the condition of the Society the donations received, and presented invoices and correspondences, all of which were read and laid before the committee for its action.

The committee thereupon discussed the best means of disposing of the supplies with a disposition to carry out the spirit of the gift.

Mr. Eckart offered a resolution that the Secretary of the Technical Society put advertisements in three of the daily newspapers of San Francisco every alternate day for six days, *i.e.*, three individual insertions, these to announce to engineers and technical men that supplies are on store at the temporary office; that they will be distributed by the Secretary to those in need of them; and that any engineer, draftsman, surveyor or technical man may call for assistance, irrespective of membership in any of the local or national societies; those in need to address the Secretary and enclose a list of the articles required by them at the present time; the Secretary to be instructed to file these wants in the order of their receipt, and to supply those who call for them, until the supplies are exhausted. Discriminating against no one, the instructions authorize the Secretary to furnish those first who call first, serving the articles as long as they will last

This resolution was seconded by Mr. Wagoner and carried unanimously by the committee members present.

The Secretary was instructed to defray all expenses out of the fund donated by eastern friends, the various donations to be placed in the hands of the Treasurer, who is to render an account of the disposition of the money.

It was also ordered that the Secretary inform the chairman of the committee, Mr. Duryea, who was absent, of the transactions of the meeting and to request him to announce to the local members of the

American Society of Civil Engineers and before the Municipal Advisory Committee of Forty, that these supplies were on hand and that they would be distributed as set forth in Mr. W. R. Eckart's resolution.

With this official authority behind him, the Secretary inserted notices in the daily newspapers as follows:

*To Engineers and Technical Men*: Through engineering societies of the East, a lot of engineering office supplies, consisting of scales, triangles, field and pocket books, instruments, paper, etc., have been sent to the Secretary of the Technical Society for gratuitous distribution to those who have been burned out. Application may be made by any engineer, draftsman, or architect by addressing OTTO VON GELDERN, 1908 Broadway, San Francisco.

EDWIN DURYEA, Jr., *Chairman of Committee.*

For a period of about one month there were daily calls for supplies by a great many representatives of the technical professions who had lost all their tools, and who, willing to work, were not able to obtain them elsewhere, even if they had had the money to pay for them.

It necessitated considerable patient work, which was done cheerfully by members of the Secretary's family and particularly by the wife of the Technical Society's Treasurer, Mrs. E. T. Schild, and Edward von Geldern, who kept a faithful record of every article that was disposed of in this way.

The supplies most in demand were drawing instruments, scales, pencils, triangles, T-squares, straight-edges, engineering pocketbooks, field books, tape-lines, inks and colors.

Papers, tracing cloth and blue-print paper were not required to such an extent, because these articles were usually furnished by the firms who employed the men, and had been obtained from the larger coast cities like Los Angeles, Portland and Seattle.

There is no doubt that a great deal of good was accomplished by this emergency help. It is true that we could not furnish every caller and every technical man with what he wanted, but we did all we could do, and distributed everything to the best of our ability and with ordinary discretion, making the supplies last as long as we could.

Here follows a list of donations as they were received from day to day at the Secretary's office:

## DONATIONS

Mrs. E. E. HOLMAN, 1020 Chestnut Street, Philadelphia:
- Office tools and drawing instruments, scales, etc.

W. G. KIRCHOFFER, Consulting Engineer, Vroman Building, Madison, Wis.:
- Office instruments.

GEORGE F. SCHILD, Naval Architect, Vallejo, Cal.:
- Office instruments, scales, maps, etc.

ARTHUR E. NORTON, Division of Engineering, Harvard University, Cambridge, Mass.:
- 1 package of triangular scales.
- 25 40° triangles.
- 25 60° triangles.

E. L. CORTHELL, Consulting Engineer, New York:
- 12 compasses, 12 ruling pens, } *from Theo. Alteneder & Son, Philadelphia.*
- 1 gr. 2H "Koh-I-Noor" pencils, *from L. & C. Hardmuth, New York.*
- 2 Vega's logarithms, *from Lemcke & Buechner, New York.*
- 2 Lufkin tapes, 100 ft., *from Patterson Brothers, New York.*
- 12 Carnegie pocketbooks, *from United States Steel Products Export Company, New York.*
- 6 Smoley's tables, *from Engineering News Publishing Company, New York.*
- 12 wooden triangles, 30°–60°, 12 wooden triangles, 45°, 300 Record thumb tacks, 1 gr. No. 312 pens, 1 gr. No. 170 pens, 24 penholders, 24 point protectors, 24 ink erasers, 24 pencil erasers, 12 4-ft. folding rules, 4 blue pencils, 3 red chalks, } *from E. G. Soltman, New York.*

Through John C. Trautwine, Jr., and by the courtesy of Williams, Brown & Earle, Philadelphia:

2 sets drawing instruments.
44 triangles, of different sizes, wood and celluloid.
9 curves of different sizes.
1 doz. pencils.
4 Sexton's omnimeters (cardboard).
1 Cox computer (paper).
73 flat scales, 12-in. long, wood.
4 flat scales, 18 in. and 24 in. long.
19 triangular scales, 12 in. long.
1 extension foot-rule, 4 ft.
68 small off-set scales, 1 in. to 6 in. long.
4 wooden protractor scales.
27 small triangular off-set scales.
13 ruling pens.
6 6-in. dividers.
6 steppers.
4 bow-pens.
1 set compass, with pencil and pen.
1 T-square.
4 doz. pen points, assorted.
1 small protractor.
1 package tables (circles, etc.).

K. J. C. Zink, Assistant to Chief Engineer, Grand Trunk Pacific Railway, Montreal, Quebec:

15 bottles drawing ink.
1 case pencils.
11 large pieces soft rubber.
12 point protectors.
2 doz. drawing pencils.
Assorted ink erasers.
1 doz. blue pencils.
1 doz. yellow pencils.
4 boxes talcum.
2 boxes writing pens.
1 bottle paste.
1 bottle white ink.
6 ruling pens.
1 scale.
2 crayons.
1 curve.
8 triangles.
12 brushes.
5 penholders.
4 T-squares.

American Society of Civil Engineers, New York:

25 sets instruments.
25 triangular scales.
25 small brass protractors.
18 straight edges, 36 in.
5 straight edges, 30 in.
2 straight edges, 42 in.
25 triangles, 60°–30°.
25 triangles, 45°.
2 Stadia slide rules.
24 tape lines.
24 field books.
24 level books.
6 rolls Imperial tracing cloth.
3 rolls, 100 yd. each, detail paper.
2 rolls profile paper.
2 rolls cross-section paper.
6 rolls economy paper
20 rolls blue-print paper.
6 bottles Columbia ink.
10 boxes tacks.
6 boxes assorted water colors.
12 doz. Paragon pencils, 6H
12 doz. Paragon pencils, 2H.
12 doz. rubbers.
6 gross pens.
2 doz. plumb bobs.
1 doz. red pencils.
1 doz. blue pencils.
12 cross-section books.

Mr. George C. Power sent a transit, to be loaned to any engineer in immediate need.

Mr. H. S. Crowe, of the Modesto Irrigation District, expressing sympathy, offered a blueprint of plans of the district.

Mr. Ernest McCullough, Chicago, sent a number of small instruments and office tools.

A number of smaller donations were sent, all of them acknowledged with the appreciation of the Technical Society, and distributed with the rest.

One hundred and ten technical men were aided by these donations; their names were taken down and the articles given them placed against them.

At the present date there are left over and undistributed the following articles, which the Technical Society may now dispose of as may be deemed best:

Stock on Hand:

5 sets of drawing instruments.
1½ doz. field books.
3 omnimeters.
1 steel tape.
4 metallic tapes.
17 plumb bobs.
20 doz. pencils.
2 boxes of rubbers.
1 roll profile paper.
3 rolls sketching paper.
3 rolls tracing cloth.
18 rolls blue-print paper.
3 Trautwine's "Pocketbooks."
1 table of logarithms.

The following books were donated. The pocketbooks were given

away, and a few of the others sold to those who could afford to pay for them.

THOS. A. EDISON:
1 doz. Trautwine "Pocketbooks."
J. T. FANNING:
"Water Supply Engineering."
CHAS. J. CHURCHILL:
Shunk's "Pocketbook."
JOHN C. TRAUTWINE, Jr.:
16 "Pocketbooks" (Trautwine of all kinds and editions).
SANFORD E. THOMPSON:
"Concrete, Plain and Reinforced."
HORACE ANDREWS:
One case, containing fourteen engineering books on different subjects.
THE ASSOCIATION OF ENGINEERING SOCIETIES, Mr. Fred. Brooks, Secretary, Boston:
One set copies of the JOURNAL from the beginning, with the exception of certain numbers which the Association does not possess.
ENGINEERING SOCIETY OF WESTERN PENNSYLVANIA, F. V. McMullin, Secretary:
"Proceedings" of the Society, excepting Volumes ii, iii, iv and vii; and a tin box filled with draftsmen's articles and small books.
ENGINEERS' CLUB OF ST. LOUIS, R. H. Fernald, Secretary:
*Transactions of the American Society of Mining Engineers*, Volumes ii, v, vi, xiv to xxvi inclusive.
*Journal of the Association of Engineering Societies*, Volumes i to xiv inclusive (1881–1895), xvi, xvii, xix, xx–xxv, xxx, xxxiii.
Report of the Mississippi River Commission, 1883.
"Tests of Metals," 1881, 1884.
O. CHANUTE, Consulting Engineer, Chicago, Ill.:
Seven boxes of JOURNALS, with a check for $75.
*Railroad Gazette* and other engineering papers.
H. G. RICHEY, Wheeling, W. Va.:
Handbook.
WESTERN SOCIETY OF ENGINEERS, J. Warder, Secretary:
Offered copies of "Proceedings" and whatever may be of use in the way of literature whenever the Society would be ready to receive it.
A. M. STEGER, Civil Engineer, Pueblo, Mexico:
Eight books on different technical subjects.
THE U. S. GEOLOGICAL SURVEY, Washington, D. C., Mr. E. M. Douglas, Geographer:
Announced under date of June 23, 1906, the shipment of one box containing books, and of a second box containing 32 steel tapes and 2 sets of drawing instruments. Mr. Douglas wrote that the steel tapes were contributed by the Lufkin Rule Company, of Saginaw, Mich.; the drawing instruments were sent by E. C. Held, of the Treasury Department; the books were contributed by various people. Messrs Bausch, Lomb, Saegmuller Company, of Rochester, N. Y., have promised to send a transit and level.
The above boxes or articles as enumerated in the letter from Mr. Douglas have not been received to date, although diligent inquiry has been made from time to time at the railway offices.
JOHN C. TRAUTWINE, Jr.:
Eleven books on different electrical subjects.

With great courtesy several publishing companies of the East offered liberal inducements in the sale of technical books to our engineers. Among these may be mentioned the Engineering News Publishing Company of New York, who offered a reduction of one third on any technical book in its catalogue.

The *Engineering Record* offered similar advantages, and stood ready, for a long time, to publish any article for the Society to aid it in its work.

The Van Nostrand Company offered a donation of books from its catalogue to the value of $250, not strictly confining itself to engineering literature. Upon the receipt of a list a shipment will be made whenever this may be expedient.

Mr. Chas. Warren Hunt, secretary of the American Society, wrote as follows:

"I am authorized to send you, for your Society, as complete a set

of our transactions as we have, as soon as you indicate that you have a place where it may be of use to engineers. I will, therefore, have a set made up ready for shipment, and as soon as I hear from you, will send them.

"At the same meeting I suggested that a number of our members in San Francisco might have lost their libraries through fire, and would probably be glad to replace at least some of the publications of this Society, and in order to make it easy for them to do so I am authorized to replace any of our publications so lost to our members, giving them a discount of 75 per cent., which will make such publications very cheap, probably somewhat less than their actual cost."

In the same manner encouraging offers were made to us that still hold good and that may be taken advantage of at any time. Similar offers were made to Mr. Teggart, librarian of the Mechanics' Institute, and he, with commendable zeal, has made many purchases since the fire for the Institute, with the main object in view of rehabilitating a technical library as soon as possible in San Francisco.

In the present library building, the first to be built on the ruins, you will find all the recent technical books that the profession is in search of usually, and I recommend that the JOURNALS, etc., now in store at my residence be turned over to the Mechanics' Institute Library for shelving.

### Other Donations.

Immediately after the catastrophe, donations were made to the Society in money, until the Secretary informed the kind donors that there was no longer any need for monetary assistance, but that the loss felt most by our engineers was the destruction of almost every technical book and journal in the town.

Of money received and expended the following statement is made:

#### Receipts.

| | | |
|---|---|---|
| May 10 | Collected at the meeting of the Engineers' Club, Philadelphia, May 5. | $25.00 |
| ,, 10 | John H. Converse, Baldwin Locomotive Works | 5.00 |
| ,, 12 | Wm. L. Austin, Baldwin Locomotive Works | 25.00 |
| ,, 12 | Wilfred Lewis, member Engineers' Club, Philadelphia | 1[illegible].00 |
| ,, 12 | G. H. Herold, Division Engineer, Great Western Railway, Re[illegible] | 5.00 |
| ,, 14 | Sale of a pocketbook | 2.50 |
| ,, 16 | Donation from the Link Belt Engineering Draftsmen, through Mr Luders | 15.00 |
| June 1 | Through Mr. W. H. Bryan, who, after having pleaded for the engineer before the Engineers' Club of St. Louis, caused the club to offer a donation of | 100.00 |
| June 2 | Engineers' Club, Philadelphia | [illegible] |
| June 4 | O. Chanute, donation | 75.00 |
| July 18 | E. M. Douglas | 75 |
| ,, 18 | Sale of a scale | 2.50 |
| ,, 18 | Sale of a tape and books | 15.00 |
| | Total | $313.75 |

#### Expenditures.

| | | |
|---|---|---|
| May 10 | Insertion in newspapers for meetings and notifications | $12.80 |
| to | Postage | 5.[illegible]0 |
| Sept. 1, | Stationery | 4.50 |
| 1906. | Expenses to obtain freight from Oakland | 2.[illegible]0 |
| | Expressage on boxes | 18.15 |
| | Telegrams | 11.05 |
| | Advertisement to call for articles to be distributed | 18.30 |
| | Labor in handling boxes and office assistance | 19.40 |
| | Stenographer and typewriter | 5.[illegible]0 |
| | | $97.10 |
| | Balance turned over to the Treasurer | 216.65 |
| | Total | $313.75 |

### Donation of Clothing.

Very soon after the fire, letters were received from Mrs. Trautwine, of Philadelphia, offering her kind offices in procuring clothing to be distributed among those in need.

Mr. George W. Dickie, the President of the Technical Society, who was in Philadelphia during the catastrophe, and who is there still, attended meetings of the Engineers' Club of Philadelphia, and on May 26 addressed the club regarding the earthquake at San Francisco and the probable destitution of the engineers of our city.

Mrs. Trautwine's communications containing her offer to send clothing to us were submitted to Mrs. Schild and to Mrs. Von Geldern, who were willing to take it upon themselves to see that donations of this character were placed where they would do most good. Mrs. Von Geldern communicated directly with Mrs. Trautwine, accepting her kind offer, and this lady thereupon entered into the spirit of trying to help others with all the enthusiasm of her generous nature, interesting all her friends in Philadelphia to lend assistance.

Although this clothing was shipped soon after the fire, it did not reach San Francisco for several months,— this is more particularly the case with a shipment from Rochester,— which caused the unfortunate condition of not being able to render aid when it would have been most appreciated, that is, at an early day after the calamity. However, when three cases arrived from Philadelphia, the ladies did everything in their power to transfer these contributions to those who were needy. Not necessarily was this restricted to any particular calling or class of people, but where it was definitely known that clothing was wanted for men, for women and particularly for children, it was given with readiness and with the idea of acting in the spirit in which the donations were made.

We have received in all five cases, containing male and female clothing, shoes, handkerchiefs, overcoats, shirts, collars and similar wear in great variety, collected from those who were willing to part with some of their apparel. It came from the families of engineers mostly. Three cases were sent by Mrs. J. C. Trautwine, Jr., of Philadelphia, and two cases by John F. Skinner, secretary of the Rochester Engineering Society; the latter were nearly two months on the way in freight transit.

Another box, promised at the time by Mr. George A. Ricker, acting chief engineer of the Pittsburg, Binghamton & Eastern Railroad Company, has not yet been received. It will be turned over to the Society as soon as it does arrive.

From the contents of this report it may be seen that the Technical Society of the Pacific Coast has not been idle.

Its members were scattered in all directions after the catastrophe, and their addresses were unknown. It was difficult to get them together; repeated calls for meetings advertised in the papers, — costly in themselves, — never accomplished more than the gathering of a few.

The interest in structural work caused the organization of a Society of Structural Engineers, for which there was an immediate field. The Technical Society might have undertaken this work, but in the earlier excitement of military rule and the loss of so much, every one had to think of something usually so near home that the thoughts for the Society's future were not uppermost. It had lost everything, even its records and its list of members, and knew not which way to turn.

It was then that the thought suggested itself to a few of the old friends of the Society to make an attempt to help others and to try, even if in a small way, whether the name of the Society and the standing of its officers might not be made the basis for an effort to lend a helping hand to the poor fellows who had lost their all and who would probably want to go to work again.

This effort was not a failure. We gave to those who did indeed appreciate the gift. While the better known engineers and those who occupied important positions were undoubtedly able to rehabilitate themselves, the younger men, architectural and mechanical draftsmen, surveyors and those who had the world before them, came only too gladly for help; and there is no doubt that whatever was given away,

was distributed wisely and well. At least, we tried to accomplish the object. This much in explanation of the motive that caused the Technical Society to enter upon the work of relief on a small scale.

The Society has still 160 members on its list. They are nearly all members of the Mechanics' Institute and they receive the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES, of which this Society is a component.

The present officers are:

President — George W. Dickie.

Vice-President — Franklin Riffle.

Secretary — Otto von Geldern.

Treasurer — E. T. Schild.

Directors — Hermann Barth, H. D. Connick, Hermann Kower, Marsden Manson and Carl Uhlig.

Herewith is appended a list of those holding membership at the present time. Most of them are in good standing, and many of them have paid their dues to January, 1907.

There is good material in our Society to do effective work, and there is no reason why it should not begin its career of usefulness again. Suggested are, at this time, affiliations with other engineering societies that have been organized since the calamity. We all know how difficult it is for any society to keep up its prosperity. There are at first periods of energy followed with absolute certainty by periods of apathy, when it takes a considerable effort to keep the organization alive. It usually depends on the devotion of six or eight so-called "standby's" to hold up sufficient interest in the society until a new period of energy is brought about.

We have the advantage of the publications made by the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES, which releases this Society from the very heavy expenditure of publishing papers. Without a current publication, an organization would sink into a lethargic condition, from which it would be impossible to revive it, and to maintain one for its individual transactions, in order to retain its specific identity, involves so great an outlay that unless the society had a very large membership, or separate means for this purpose, it would soon succumb. The past history of many of these organizations, once flourishing and active, has established this fact beyond any doubt whatever.

The Technical Society has survived all its vicissitudes since 1884, and your Secretary trusts that its sphere of usefulness may begin with renewed vigor now. It is your affair to make it do so.

In the name of the members of the Technical Society I wish to thank all those kind-hearted and thoughtful men and women who helped us when there was need for help.

I have enumerated them all, as far as I know, but if any have been overlooked, they are included among those to whom the gratitude and appreciation are due, not only from the Technical Society, but from every one who follows a technical calling, and who, directly or indirectly, derived a benefit from our efforts to help.

Respectfully submitted,

OTTO VON GELDERN, *Secretary.*

It was moved that the recommendations made by the Secretary in his report be accepted and that he be instructed to turn over to the Mechanics' Institute Library all the books now in his charge, for the purpose of shelving them in the library building and making them available for use at once. — Carried.

Mr. Bennett moved that as many of the tools as may be needed be turned over to the Mechanics' Library, for the purpose of establishing a "*working corner*" in the library hall, for technical men, a closet to be arranged, with key, for the benefit of our members, where they may obtain drafting tools, inks, papers and office requisites for making sketches

or drawings in the library, if they should wish to do so, the librarian to arrange two or more drawing tables for this purpose.— Carried.

The Secretary was instructed to make the best possible use of what little there would be left after that, by either disposing of it among the members of the Society, or by giving it to those who may still be in need.

In the matter of the supplies, still expected from the United States Geological Survey, the Secretary was instructed to report upon the arrival of the cases, and to turn the books over to the Mechanics' Library for immediate shelving: the tape lines to be taken into consideration upon their arrival.

The Secretary was instructed to convey the thanks of the Technical Society of the Pacific Coast to every one who in the kindness of heart offered and extended help to the engineers during a period of great trial.

*Voted*, That these proceedings, together with the Secretary's report, be published in full in the Journal of the Association of Engineering Societies and that one hundred extra copies be struck off and distributed among the friends of the Society.

Adjourned.

Otto von Geldern, *Secretary*.

# Association of Engineering Societies.

Vol. XXXVII. OCTOBER, 1906. No. 4.

## PROCEEDINGS.

### Boston Society of Civil Engineers.

Boston, September 19, 1906. — A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.55 o'clock p.m., President Frank W. Hodgdon in the chair; one hundred and six members and visitors present.

The record of the last meeting was read and approved.

Messrs. Richard Gardner Hartshorne and Edward Austin Tucker were elected members of the Society.

The Secretary read a memoir of Eddy Elbert Young, a member of the Society, which had been prepared by Mr. Howard A. Carson, a committee of the Society.

On motion of Mr. Winslow, the thanks of the Society were voted to the Hon. John B. Martin, Penal Institutions Commissioner of Boston, for the use of the city steamer "Monitor," on the occasion of the trip to Deer Island this afternoon.

On motion of Mr. Kimball, the thanks of the Society were voted to Mr. E. B. Winslow, president of the Portland Stoneware Company, and to other officials of that company, for the courtesies and generous entertainment extended to members of the Society on the occasion of the trip to Portland, Me., August 3 to 5, 1906.

The discussion of the evening was on "Reinforced Concrete Construction," and was opened by Mr. Chester J. Hogue with a brief description of reinforced concrete factory construction as a type. He was followed by Messrs. L. C. Wason, J. R. Worcester and L. J. Johnson.

On account of the lateness of the hour, it was voted, on motion of Mr. L. F. Rice, to continue the discussion at a future meeting, to be held at an early date, as determined by the Board of Government.

Adjourned.

S. E. Tinkham, *Secretary*.

Boston, October 5, 1906. — A special meeting of the Boston Society of Civil Engineers was held in the library, Tremont Temple, 8 o'clock p.m.; sixty-two members and visitors present.

In the absence of the President and Vice-Presidents, Mr. J. R. Worcester was elected chairman.

The meeting was devoted to a continuation of the discussion on "Reinforced Concrete Construction," begun at the last regular meeting. Messrs. S. E. Thompson, William Parker, L. J. Johnson, L. C. Wason, C. J. Hogue, E. S. Larned and others took part in the discussion.

Adjourned.

S. E. Tinkham, *Secretary.*

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Boston, October 17, 1906. — A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 8 o'clock P.M., President Frank W. Hodgdon in the chair; thirty-five members and visitors present.

The records of the last regular meeting and of the special meeting of October 5 were read and approved.

Messrs. John R. Rablin, John S. Rankin and Edward B. Richardson were elected members of the Society, and Mr. Claude A. Palmer was elected an associate.

The President announced the deaths of the following members of the Society: John E. Cheney, who died September 25, 1906, and Nelson Spofford, who died October 3, 1906; and on motion it was voted to appoint committees to prepare memoirs. The President has appointed the following as these committees: On memoir of John E. Cheney, Messrs. E. D. Leavitt, G. F. Swain and F. H. Fay; and on memoir of Nelson Spofford, Messrs. Frederick Brooks and Richard A. Hale.

The President then introduced as the speaker of the evening Mr. Charles Moore, chairman of the Board of Directors of The Submarine Signal Company, who gave an informal talk on "The Submarine Signal," which was illustrated by lantern slides. Prof. Lucian I. Blake, consulting engineer of The Submarine Signal Company, and Mr. Arnold B. Johnson, chief clerk of the United States Lighthouse Board, also gave very interesting accounts of the working of the submarine signals.

On motion of Mr. E. W. Howe it was voted: That the Society express its sincere appreciation of the courtesies extended to it by The Submarine Signal Company on the trip down Boston Harbor to inspect the operation of the submarine signal system and for the interesting illustrated description to which we have just listened.

Adjourned.

S. E. Tinkham, *Secretary.*

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## Sanitary Section.

Boston, Mass., October 10, 1906. — A regular meeting of the Sanitary Section was held at the Copley Square Hotel, Vice-Chairman Weston presiding. Forty-two members and guests were present.

A paper upon "The Relation of the Suspended Matter in Sewage to the Problem of Sewage Disposal" was presented by H. P. Eddy and A. L. Fales. The paper was illustrated with lantern slides and was discussed by Messrs. R. S. Weston, George A. Carpenter, H. W. Clark, C.-E. A. Winslow, E. B. Phelps and others.

William S. Johnson, *Clerk.*

# Association of Engineering Societies.

Vol. XXXVII. NOVEMBER, 1906. No. 5.

## PROCEEDINGS.

### Engineers' Club of St. Louis.

St. Louis, October 17, 1906. — The 621st meeting of the Engineers' Club of St. Louis was held at the Club rooms, 3817 Olive Street, Wednesday evening, October 17, 1906. President Layman presided. Fifty-seven members and twenty-one visitors were present.

The minutes of the 620th meeting were read and approved and the minutes of the 411th and 412th meetings of the Executive Committee were read.

It was moved by Mr. Bryan, in line with the suggestion of the Executive Committee, that $100 be transferred from the General Fund to a new fund to be designated "Local Entertainment Fund," and that the present Entertainment Fund be hereafter designated "General Entertainment Fund." Mr. Robert Moore suggested that the name of the new fund be "Special Entertainment Fund." With the change in the name suggested by Mr. Moore the motion was carried.

The application for membership in the Club of Alfred George Shutt was presented.

Mr. Edwin Dwight Smith was elected to membership in the Club.

Owing to the illness of Mr. Zeller, chairman of the Committee on Membership, and to the absence from the city of Mr. McCulloch, a second member of the committee, the President of the Club suggested that Mr. Bryan act as temporary chairman of the committee and that the Chair be given power to appoint two assistants to Mr. Bryan, to serve during the absence of Mr. Zeller and of Mr. McCulloch. The suggestion of the President was approved by the Club.

A meeting of more than ordinary interest resulted from the spirited and efficient discussion of the "bridge situation," by the following gentlemen: Messrs. Robert Moore, Albert T. Perkins, consulting engineers to the Terminal Railroad Commission; Julius Pitzman; M. L. Holman; Edward Flad; Geo. Hannauer, superintendent Wiggins Ferry Company; H. J. Pfeifer; R. S Colnon; S. Bent Russell; R. H. Phillips; P. M. Bruner.

Owing to the unusual interest manifested, the hour was late when the meeting adjourned.

R. H. Fernald, *Secretary.*

St. Louis, November 7, 1906. — The 622d meeting of the Engineers' Club of St. Louis was held in Memorial Hall, Museum of Fine Arts, 19th and Locust streets, St. Louis, on Wednesday evening, November 7, 1906, at eight o'clock. President Layman presided. There were present about sixty members and between two hundred and fifty and two hundred and seventy-five visitors.

The meeting was an "open" meeting, and many friends, including a large number of ladies, responded to the invitation of the Club.

Promptly at eight o'clock President Layman called the business meeting to order. Upon motion of Mr. Brenneke the last five past-presidents were appointed as a nominating committee for the nominating of officers for the next year. The five gentlemen elected were Messrs. Edward Flad (chairman), J. A. Ockerson, J. L. Van Ornum, J. H. Kinealy and E. J. Spencer.

The President announced the following committees on resolutions:

On the death of Mr. Wm. Wise: Robert McMath, chairman; Robert Moore, M. L. Holman. On the death of Mr. A. H. Zeller: Edward Flad, chairman; W. G. Brenneke, R. H. Fernald.

The formal business meeting then adjourned.

At 8.30 o'clock the President introduced the speaker of the evening, Mr. Richard L. Humphrey, member American Society of Civil Engineers; consulting engineer, secretary National Advisory Board on Fuels and Structural Materials. Mr. Humphrey's lecture on the San Francisco earthquake was of unusual interest, and the profusion of excellent lantern slides brought the conditions on the Pacific Coast very near to all who were fortunate enough to be present.

At the close of the lecture the galleries of the Museum of Fine Arts were thrown open for an informal reception.

A hearty vote of thanks was extended by President Layman to Mr. Humphrey for his interesting and instructive lecture.

Adjourned.

R. H. Fernald, *Secretary.*

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## Boston Society of Civil Engineers.

Boston, Mass., November 21, 1906. — A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 8 o'clock p.m., President Frank W. Hodgdon in the chair; fifty-two members and visitors present.

The record of the last meeting was read and approved.

Messrs. Raymond C. Allen and George E. Harkness were elected members of the Society.

The President announced the death of Freeman C. Coffin, Senior Vice-President of the Society and chairman of the Sanitary Section, which occurred November 11, 1906.

On motion of Mr. French, the President was requested to appoint a committee to prepare a memoir. The President appointed the following members as that committee: Leonard Metcalf and William S. Johnson.

The Secretary read a letter from Dr. Clarence J. Blake, presenting to the Society a set of 13 volumes of the Pacific Railway Surveys as a memorial of his father, John H. Blake, first secretary of the Society.

On motion of Mr. Brooks, the officers of the Society were directed to express to Dr. Blake the thanks of the Society and its appreciation of his valuable gift.

The President then introduced Mr. Frederic A. Kummer, chief engineer United States Wood Preserving Company, who read a paper on "The Development of Wood Pavements." The paper was illustrated with lantern slides.

Mr. A. L. Plimpton, with the aid of a large diagram, explained the method used in laying the street railway track in Washington Street.

On motion of Mr. Manley the thanks of the Society were voted to Mr. Kummer and the company which he represented for the very interesting paper which he had just read, and for the courtesies extended to the Society this afternoon on the occasion of the excursion to examine the wood pavement being laid on Washington Street.

Adjourned.

S. E. Tinkham, *Secretary.*

## Montana Society of Engineers.

Butte, Mont., November 10, 1906. — The regular meeting for November, 1906, was called to order in the Society room, 225 North Main Street, Saturday evening, November 10. After waiting for some time and no quorum appearing, the meeting was adjourned to Saturday evening, November 17, 1906.

Clinton H. Moore, *Secretary.*

Butte, Mont., November 17, 1906. — The adjourned November meeting of the Society was called to order on the above date at 8 p.m., in the Society room, 225 North Main Street. Quorum present. President Dunshee presided. Minutes of last two meetings read and approved. Application for membership by Fred J. Brule read and approved and ballots for same ordered circulated. Geo. A. Griggs and Sedman W. Wynne elected to membership by a unanimous vote. It was decided to hold the next annual meeting in Butte, January 10, 11, 12, 1907, and the following Committee on Arrangements was selected. Messrs. Moulthrop, McArthur, Barker, Dunshee and Moore. Committee on Nomination of Officers for next year presented the following names:

President — Edward C. Kinney.

First Vice-President — Archer E. Wheeler.

Second Vice-President — Arthur H. Wethey.

Secretary and Librarian, Clinton H. Moore.

Treasurer and Member of the Board of Managers of the Association of Engineering Societies — Sam'l Barker, Jr.

Trustee — Azelle E. Hobart.

Signed — C. W. Goodale, Eugene Carroll, Geo. E. Moulthrop, Committee.

The Committee on Resolutions on the death of Thos. T. Baker reported the following:

*Whereas*, In the death of Thomas T. Baker the Montana Society of Engineers has suffered a great loss, and desiring to place on record its

appreciation of his high character, both as an engineer and a man, and of his tireless energy displayed in helping to build up the state of Montana for the past forty years; therefore be it

*Resolved*, That we tender to his bereaved family our sincere sympathy, and that a copy of these resolutions be spread on the minutes of this Society and another be sent to the family of the deceased.

A. E. Hobart,
Samuel Barker, Jr.,
Robert A. McArthur,
*Committee.*

Adopted.

On application, Edward K. Triol was transferred to the class of corresponding members. The Secretary called the attention of the members to several new works, gifts to the Society, and he was instructed to acknowledge the receipt of the same.

Adjourned.

Clinton H. Moore, *Secretary.*

## Technical Society of the Pacific Coast.

San Francisco, November 9, 1906. — Regular meeting called to order at 8.30 p.m.

The minutes of the last regular meeting of October were read and approved.

The members discussed in various ways the plan of a future activity for the Society, and concluded to take up the structural work in the rehabilitation of San Francisco as one of the most important engineering subjects at the present time.

The Secretary was instructed to write to a number of engineers who make a specialty of reënforced concrete construction, requesting their coöperation in this matter by the contribution of papers, leading to a general discussion of this important work.

The following names were suggested: Prof. C. B. Wing, Stanford University; Prof. C. Derleth, Jr., University of California; Mr. M. C. Couchot, San Francisco; Mr. C. F. Wieland, San Francisco; Mr. L. A. Hicks, San Francisco; Mr. J. C. Bennett, San Francisco.

The Secretary thereupon drew up the following program for the meeting to be held on December 7, 1906, which was subsequently approved by the Executive Committee.

Technical Society of the Pacific Coast. Mechanics' Institute.

The next regular meeting of the Society will be held on Friday evening, December 7, at eight o'clock, in the hall of the Mechanics' Library, 99 Grove Street, on the old Pavilion site.

The evening will be devoted to the discussion of the important subject of "Reënforced Concrete Structures."

The following contributions have been communicated to the Secretary and will be brought up:

1. "The Mechanics of Reënforced Concrete." By Prof. Charles B. Wing.
2. "The Long Beach Hotel Accident." By Lewis A. Hicks.
3. "Designs of Buildings under Construction." By C. F. Wieland.

On similar subjects that have not been announced by title to the Secretary in time for this notice, the following gentlemen have indicated their willingness to contribute: Prof. Charles Derleth, Jr., Mr. M. C. Couchot, Mr. Jas. C. Bennett.

The Technical Society desires a full gathering of all its members, in order to lay out a plan for future work. It has the men and it should create the opportunity.

It is a part of the program to make the arrangements for the usual semi-annual dinner, and the committees will be appointed to take this matter in hand.

Members and their ladies contemplate holding a reunion to exchange greetings for the first time since the catastrophe, and in order to make the necessary arrangements for this a full meeting is desirable.

A Nominating Committee will be appointed to select a ticket of officers for the ensuing year.

This notice is an invitation to any one who may receive it. All who are interested in technical subjects are cordially invited to attend this meeting, whether members of the Society or not.

Inspect the new technical books that have been placed on the shelves and purchased by the Mechanics' Library.

All members are urgently requested to be present.

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Meeting adjourned.

Attest:

OTTO VON GELDERN, *Secretary*.

# Association of Engineering Societies.

Vol. XXXVII. DECEMBER, 1906. No. 6.

## PROCEEDINGS.

### Engineers' Club of St. Louis.

St. Louis, November 21, 1906. — The 623d meeting of the Engineers' Club of St. Louis was held at the Club Rooms, 3817 Olive Street, Wednesday evening, November 21, 1906. President Layman presided. Thirty-three members and thirty visitors were present.

The minutes of the 621st and of the 622d meetings were read and approved, and the minutes of the 413th meeting of the Executive Committee were read.

Mr. Alfred George Schutt was elected to membership in the Club.

Applications for membership were presented from August Emanuel Bjork, Daniel Breck, Francis E. Schwentler, Eugene Tritle Spencer.

A letter from Mr. Albert T. Perkins, expressing his appreciation of the courtesy extended to him by the Club, was read by the Secretary, and also a letter stating that Mr. Selden could not be present to participate in the evening's discussion as had been hoped.

The President announced the Committee on Extension of Membership to be Messrs. W. H. Bryan (chairman), W. H. Henby, H. C. Toensfeldt.

Upon motion of Mr. Brenneke the Executive Committee was instructed to make the proper arrangements for the annual dinner of the Club.

The committee appointed for nominating officers for 1907 presented the following report:

St. Louis, November 20, 1906.

To the Engineers' Club of St. Louis, St. Louis, Mo.:

*Gentlemen,* — Your Nominating Committee submits herewith the names of candidates selected for the various offices for the ensuing year:

President — Mr. E. R. Fish.
Vice-President — Mr. W. G. Brenneke.
Secretary and Librarian — Mr. R. H. Fernald.
Treasurer — Mr. E. E. Wall.
Directors — Mr. R. S. Colnon and Mr. Richard McCulloch.
Members of the Board of Managers of the Associated Societies — Mr. A. P. Greensfelder and Mr. R. Lincoln Murphy.

Respectfully submitted.

(Signed) J. A. Ockerson,
J. L. Van Ornum,
J. H. Kinealy,
E. J. Spencer,
Edw. Flad, *Chairman,*
*Committee.*

Owing to the absence of Mr. McMath the Committee on Resolutions on the death of Mr. William Wise was unable to report at this meeting.

The report of the Committee on Resolutions on the death of Mr. A. H. Zeller was presented by Mr. Flad. The report was ordered spread on the records of the Club, and copies of the report were ordered sent to the members of the family and to the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES for publication.

Letters from Mrs. F. C. Case, daughter of Mr. William Wise, and from Mr. William F. Zeller, brother of Mr. A. H. Zeller, were read, expressing their appreciation of the action of the Club at the time of the deaths of Mr. Wise and Mr. Zeller.

Upon motion of Mr. Brenneke the Executive Committee was instructed to make a report on the question of honorary membership, as it is felt by some that the present section of the constitution relating to the subject is not what it should be.

The discussion of the evening upon "Structural Lessons from the San Francisco Fire and Earthquake" was opened by Prof. J. L. Van Ornum, who illustrated his paper upon the subject by appropriate lantern slides.

The discussion was instructive, spirited and concise, the following gentlemen having prepared especially for the evening's program: W. H. Bryan, A. O. Cunningham, E. B. Fay, R. L. Murphy, H. C. Toensfeldt and Richard L. Humphrey of the structural materials department of the government testing plant.

A valuable addition to the discussion, as well as to the general pleasure of the evening, was contributed by a guest, Prof. K. E. Hilgard, C. E., of Zürich, Switzerland, who was formerly president of the Civil Engineers' Society of St. Paul, and bridge engineer for the Northern Pacific. Professor Hilgard extended a cordial invitation to the members of the Engineers' Club of St. Louis to present themselves at the headquarters of the society in Zürich, of which he is now president.

Adjourned.

R. H. FERNALD, *Secretary.*

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## The Civil Engineers' Club of Cleveland.

REGULAR MEETING, OCTOBER 9, 1906, at the Club rooms, called to order by the President, at 8.15 P.M. Present, thirty-nine members and ten visitors.

Minutes of two preceding meetings read and approved.

Applications for active membership of E. Williams Dennison, Claude F. Mullen and William H. Parish, approved by the Executive Board, were read.

The tellers reported the election to active membership of George Lyman Grimes, Thomas Seth Kemble and Burt Raymond Weidenkopf; and a tie vote on the proposition to discontinue the subscription to the JOURNAL and membership in the Association of Engineering Societies (23–23).

The Secretary read a letter from Mr. F. H. Richards, a corresponding member, strongly urging the continuance of the present arrangement as

to the Association of Engineering Societies, together with a circular letter from Mr. Fred. Brooks, Secretary of the Association, outlining his plans for the JOURNAL and requesting papers for publication

Mr. Lane moved that the Club's subscription to the JOURNAL be reduced 50 per cent. (no second). Mr. Green moved that the Executive Board be given authority to reduce subscriptions 50 per cent. if in its opinion it could be done without detriment to the Club, and if it could find means of apportioning the remaining subscriptions equitably. Carried.

On motion of Mr. Green an informal rising vote was taken: First, as to how many wished to retain the JOURNAL as at present; and second, as to how many would be willing to pay $1.00 over and above the present dues for the privilege of retaining the JOURNAL. On the first proposition the vote was twelve for and twenty-five against retaining the JOURNAL. On the second proposition the vote was fifteen in favor of paying $1.00 extra and twenty-two against. The Secretary presented a verbal report of a special committee of the Executive Board on amalgamation with the Electric Club, stating that the Committee had attended the meeting of that Club on the 3d inst., and that it had had a meeting since with a similar committee of the Electric Club, appointed at that meeting, and had agreed in a general way on the terms of such an amalgamation, which were to be stated in a proposition to be submitted by the Electric Club to the Civil Engineers' Club. Mr. E. P. Roberts, President of the Electric Club, was then given the floor and submitted a formal proposition.

On motion of the Secretary this was referred to the existing committee, with authority to prepare a letter ballot, to be canvassed at the next meeting of the Club, if possible, setting forth in detail the terms of the proposition. Resolutions on the death of Mr. Charles Paine, first president and an honorary member of the Club, prepared by Messrs. Rice, Burgess and Paul, as a committee, were read by the Secretary and adopted. The paper of the evening, describing the evolution of ore and coal-handling machinery along the lakes, and illustrated by lantern slides, was read by Mr. C. H. Wright, who humorously called his subject "Pork," having in mind the southern hotel keeper who kept a supply of salt pork always on hand for use should he fail to get anything else to serve his guests.

After adjournment lunch was served.

Adjourned.

JOE. C. BEARDSLEY, *Secretary.*

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REGULAR MEETING, NOVEMBER 13, 1906, at the Club rooms, called to order by the President at 8.15 P.M. Present, forty-five members and visitors.

Minutes of the preceding meeting read and approved.

The applications for active membership of Harold Bentley Anderson, Carroll Wilder Brown and John Elmer Linabury, approved by the Executive Board, were read.

It was announced that Mr. Cox has requested to be relieved of the chairmanship of the New Quarters Committee and that the President has appointed Mr. Wright in his place.

A letter from Mr. N. T. Harrington was referred to, in which he ex-

pressed himself willing to enlarge the paper read before the club at the January meeting, " Suction Gas Producers for Power Purposes," and prepare same for publication in the JOURNAL. Mr. Harrington had been requested to do so, in response to an appeal from Mr. Fred. Brooks, Secretary of the Association of Engineering Societies, for new material for publication in the JOURNAL, to which the paper of the evening is expected to serve as a further contribution.

The tellers, Messrs. Ullmer and Daniels, reported the election to active membership of E. Williams Dennison, Claude F. Mullen and William H. Parish.

Mr. Chas. H. Wright reported in behalf of the committee on the amalgamation of the Electric Club with the Civil Engineers' Club (which committee coöperated with a similar committee appointed by the Electric Club), stating that although terms had been agreed upon as per signed memorandum of agreement attached, and although the committee had followed instructions received at the last meeting and prepared a ballot on the question, which was printed and all ready to be mailed to the members, so as to be canvassed at this meeting, it was deemed advisable to withhold this ballot indefinitely and to drop the matter until the Electric Club take action warranting the canvassing of this ballot. The committee arrived at this decision after learning that the Electric Club at the last meeting has set aside the vote it canvassed, which resulted in an expression in favor of the amalgamation and decided to lay the matter on the table indefinitely pending the preparation of amendments to the constitution covering the question of amalgamation or disbanding.

Mr. Horner voiced the Club's sentiments in indorsing the committee's decision relative to taking no further action until the Electric Club decides on something definite.

The President announced that the report of the New Quarters Committee, presented at the last meeting of the Executive Board, has been accepted and the committee instructed to report at this meeting for final action.

Mr. Wright, the chairman of this committee, accredited Mr. Allen with doing the largest share of the work of the committee, and stated that quarters in a number of buildings have been inspected and that, considering location, price, adaptability for clubroom purposes, a suite of rooms 714–719 inclusive in the Caxton Building commends itself as the most favorable. These quarters, covering an area of 2 000 sq. ft., as against 1 500 sq. ft. in the present quarters, can be secured at a rental price of $1 200 per annum for the first year and $1 320 for the two subsequent years of a three-year lease. The rooms lend themselves better for a desirable division into assembly room, library, billiard and pool-room than other rooms inspected or the present quarters.

These rooms can be occupied by about the first of the year and no rental will be charged before April 1, 1907, unless the lease on the present quarters can be disposed of before that time, which marks the expiration of the Club's arrangement with the Associated Technical Clubs.

To allay the fears of some members relative to elevator service, the committee was assured that ordinarily elevators run until 10 P.M., but that on nights when the Club holds meetings the service will be extended till 11 or 12 P.M., if necessary. The committee received the further

promise that the partitions are to be changed to suit the wishes of the Club; likewise the decorations, including the lighting fixtures.

The committee further recommends that the Club close the lease in its own name and that the Club duly consider the raising of the necessary money to meet the rental, which is higher than the Club's contribution to the Associated Technical Clubs.

The President supplemented the report by stating that the Executive Board expects to cut down the subscription to the JOURNAL by 50 per cent., which will mean a saving of approximately $400 per year, and this, added to the Club's share in the present arrangement on quarters (approximate $1 000), will more than equal the rental price of the new quarters. For this reason the Executive Board voted to accept the proposition from the Caxton Building Company, without awaiting the action of the other clubs.

After a brief discussion a motion was made by Mr. Lane and seconded by Mr. Nelles to accept the report of the New Quarters Committee, to close the lease for the quarters in the Caxton Building referred to and to move as soon as arrangements can be completed.

This was unanimously carried.

Following a brief discussion on the Club's relation to the other three clubs sharing the quarters, a motion was made by Mr. Wright and seconded by Mr. Nelles that the Club withdraw from the arrangement with the Associated Technical Clubs at the expiration of the term of agreement and that the Secretary notify these clubs of the action and extend to them an invitation to move with the Club as its tenants.

Motion unanimously carried.

Mr. Hanlon, as chairman of the Grade Crossing Committee, sent in a telephone message referring to the report made at the February meeting, and stating that his committee is not prepared to submit a final report until a later meeting.

After some discussion Mr. Lane made a motion that the Club recommend not to allow any overhead crossings with clearance less than 21 ft. and that the committee be continued to further investigate the subject.

Carried.

A letter from General Smith, chairman of the High Level Bridge Committee, was read promising a report from his committee for the next meeting and explaining why the committee had not reported before.

Professor Benjamin, chairman of the Building Code Committee, sent word that the work of his committee would be reported on by either Mr. McGeorge or Mr. Barnum. Neither of the gentlemen being present the report was not received.

No reports were received from the Water Pollution Committee, Committee on Code of Ethics and Scale of Fees, or City Dock Improvement Committee.

The paper of the evening was read by Mr. Geo. Velten Steeb on the subject of "Fire Protection Engineering" and was followed by a very interesting discussion, in which the President, a number of members and visitors participated.

On motion of Mr. Palmer the Club extended a vote of thanks to Mr. Steeb for his valuable paper and willing services to the Club.

Adjourned.

DAVID GAEHR, *Acting Secretary.*

Regular Meeting, December 11, 1906, at the Club rooms, called to order by the Vice-President at 8.00 P.M. Present, thirty-two members and four visitors. Minutes of preceding meeting read and approved.

Application for active membership of Clarence W. Courtney, approved by the Executive Board, was read. The tellers, Messrs. W. M. Allen and H. M. Lucas, reported the election to active membership of Messrs. Harold Bentley Anderson, Carroll Wilder Brown and John Elmer Linabury; and a unanimous vote in favor of transferring $750.00 from the Permanent to the General Fund.

The Secretary submitted a brief verbal report of progress from the House Committee, stating that two of the three clubs in the Association had signified their intention of becoming tenants of the Civil Engineers' Club in the new quarters; and that the moving would probably take place about January 1, next.

The paper of the evening was a description of the dock extension work of the Lake Shore & Michigan Southern Railroad during the past season at Ashtabula Harbor, by Mr. Rote. An extended discussion followed, taken part in by Messrs. Nelles, Gaehr, Perrine, Wright and others.

Adjourned.

Joe. C. Beardsley, *Secretary*.